AD-A149 281 RELATIVE PERFORMANCE OF MICRO AND MAINFRAME COMPUTERS (U) GEORGIA INST OF TECH ATLANTA PRODUCTION AND DISTRIBUTION RESEARCH CENTER M GOETSCHALCKX ET AL. 1/1

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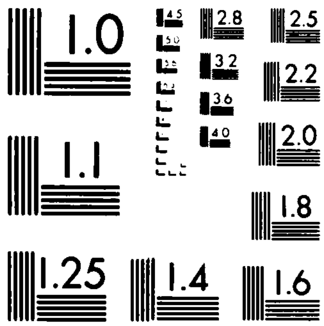
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Georgia Institute of Technology

RELATIVE PERFORMANCE OF MICRO AND MAINFRAME COMPUTERS

by

Marc Goetschalckx
Yavuz Bozer

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PRODUCTION and DISTRIBUTION RESEARCH CENTER

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Abstract

This article compares the relative performances of two typical operations research algorithms implemented on an IBM PC microcomputer and on a CDC Cyber 6400 mainframe computer. The basis of comparison is the computation time expressed in CPU seconds. The first algorithm performs exclusively integer operations, while the second algorithm performs primarily real arithmetic and transcendental functions. For the integer algorithm the speed ratio is 2.14 or 2.65 depending on the accuracy of the PC, for the real algorithm the speed ratio is 3.6. In general, the speed ratio is approximately equal to 3 to 1, which is extremely favorable for the microcomputer, considering the relative cost of CPU time on each machine.

Algorithm Using Integer Arithmetic

The integer algorithm is a branch and bound algorithm for the solution of the asymmetric traveling salesman problem based on the algorithm by Little et al. (1963). The program was coded in the Pascal language, see Jensen and Wirth (1975), and based upon the code given in Syslo et al. (1983). The branch and bound algorithm searches depth first and finds lower bounds by the row and column reduction technique.

A second version of the program is obtained by modifying the above algorithm to solve symmetric traveling salesman problems. Based on Jonker et al. (1980), a single row and column exchange is performed on the symmetric matrix to generate an asymmetric matrix which incorporates implicitly 50% of the tour elimination constraints. The asymmetric problem is then solved using the code given by Syslo et. al.

The program was compiled on the IBM PC with the Microsoft Pascal compiler (version 3.13) with all the debug options disabled to generate the fastest code. Exactly the same program was compiled on the CDC Cyber with the Pascal 6000 compiler again with all debug options disabled. The reported solution times are for the computation phase only, excluding any time required for input and output. On both computers the algorithm executed completely in memory. It must be observed that the accuracy is not equal for both computers. The Cyber has 60 bit integer numbers. The algorithm was implemented on the IBM with 16 bit and 32 bit integer numbers. As long as the elements of the cost matrix are smaller than 1000, the 16 bit accuracy is sufficient. The 32 bit accuracy allows values as large as 2.15×10^9 and is sufficient for all practical purposes.

Several problem instances were compared. Two of the problems were taken from the literature: a 10 city problem from Barachet (1957) and a 25 city problem from Held and Karp (1962). A comparison of the execution times in seconds is given in Table 1 for 16 bit accuracy and in Table 2 for 32 bit accuracy. The average speed ratio is 2.14 for 16 bit and 2.65 for 32 bit accuracy, i.e. the microcomputer is less than three times slower than the mainframe computer. The increase in accuracy from 16 to 32 bits increases the IBM PC execution times by 23%.

Table 1. Comparison of Execution Times for the 16 bit Integer Algorithm

Problem	CDC CYBER		IBM PC		Ratio	
	sym	asym	sym	asym	sym	asym
10 city	1.23	0.92	2.64	1.98	2.15	2.15
11 city	21.80	12.54	47.07	26.75	2.16	2.13
12 city	3.39	2.77	7.25	5.87	2.14	2.12
25 city	1005.06	489.76	2137.48	1045.67	2.13	2.14

Table 2. Comparison of Execution Times for the 32 bit Integer Algorithm

Problem	CDC CYBER		IBM PC		Ratio	
	sym	asym	sym	asym	sym	asym
10 city	1.23	0.92	3.24	2.48	2.63	2.70
11 city	21.80	12.54	58.00	32.36	2.66	2.63
12 city	3.39	2.77	8.96	7.30	2.64	2.64
25 city	1005.06	489.76	2644.23	1293.66	2.63	2.64

Algorithm Using Real Arithmetic

The real algorithm finds the optimal picking sequence of items to be picked from both sides of an aisle in a warehouse. The optimal sequence is found by computing the shortest path in a directed network, where each node has at most two predecessor and two successor nodes. The number of nodes is equal to 2NM+N+M+2 where N and M are the number of items to be sequenced on either side of the aisle. The length of the arcs is based on the Euclidean distance between the items corresponding to the nodes and involves square root calculations. The network structure is implicitly represented in a dynamic programming algorithm. Further details can be found in Goetschalckx and Ratliff (1984).

The program was written in the Pascal language and compiled with the same parameters as in the previous section. The IBM PC used the Intel 8087 numerical coprocessor to perform all real arithmetic. Again computation times exclude all input and output operations and the algorithm executed completely in memory. The IBM used a 64 bit real number and the Cyber used a 60 bit real number. As far as the above algorithm is concerned these accuracies are equivalent.

Several problem instances of different sizes were compared. The number of items to be sequenced was set equal to 24, 48 and 96. The number of nodes was then equal to 314, 1202 and 4706 respectively. For each problem size, three replications were run. A comparison of the execution times in seconds is given in Table 3. The average speed ratio is 3.60, i.e. the microcomputer is less than four times slower than the mainframe computer.

Table 3. Comparison of the Execution Times for the Real Algorithm

Items	CYBER	IBM	Ratio
24	0.08	0.28	3.50
48	0.29	1.06	3.66
96	1.14	4.14	3.63

Conclusions

The average speed ratio of an IBM PC microcomputer with Pascal programs to a CDC Cyber mainframe is less than three for all integer algorithms to less than four for real algorithms. This is a very favorable ratio for the microcomputer, considering the cost of one CPU second on each computer.

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