

Multiprocessing of Combinatorial Search Problems

Benjamin W. Wah, Guo-jie Li, and Chee Fen Yu
Purdue University

Multiprocessor solutions to complex science and engineering problems require an effective representation of the problem and an efficient search. Functional requirements for search algorithms must open up a variety of architectures for any problem.

Multiprocessing refers to the concurrent execution of processes (or programs) in a computer hardware complex with more than one independent processing unit.¹ Conventionally, multiprocessing is defined as a centralized computer system with central processors, input-output processors, data channels, and special-purpose processors.

With the advent of VLSI technology, it has become cost effective to include a large number of general- and special-purpose processors in a multiprocessing system. The definition of *multiprocessing* has been extended to systems such as multiprocessors, systolic arrays, and dataflow computers. In this sense, parallel processing and multiprocessing can be considered synonymous. Examples of such systems range from the IBM 360 computers with channels, Illiac IV, Staran, Cm*, Trac, MPP, and the Cray X-MP to the latest fifth-generation computer system.

Major Issues of multiprocessing

In using a multiprocessing system to solve a given problem, tremendous effort can be spent in designing a good parallel algorithm. The objective is to obtain an algorithm with a speedup proportional to the number of processors over the best available serial

algorithm. This must be done within the architectural constraints, and it involves trade-offs in computation time, memory space, and communications requirements.

The applicability of multiprocessing to the problem is also an important issue. The problem should be *polynomially solvable by a serial computer*. Intractable problems with complexity that is exponential in respect to problem size cannot be solved in polynomial time* unless an exponential number of processors are used.² This is, of course, technologically infeasible for large problems. For example, if the best serial algorithm requires 2^N micro seconds to solve a problem of size N , it would require 2^{60} microseconds, or 366 centuries, to solve a problem of size 60. Assuming that a linear speedup is possible, it would require 2^{60} processors to solve the problem in approximately one second, and 2^{60} processors to solve the problem in 20 minutes. For intractable problems, approximate solutions should be used in order to complete the algorithm in a reasonable time.

Multiprocessing is generally used to improve the computational efficiency of solving a given problem, *not to extend the solvable problem space of the problem*. Suppose that it takes N^k units of time to solve a problem of size N , where k is a constant (≥ 1). Assuming a linear speedup, a parallel algorithm with N processors in N^k units of time can solve problem of size $N^{k+1/2}$. For $k=3$, this size is $N^{3.5}$. Similarly, for a serial algorithm that takes k^N , $k > 1$ units of time to solve a problem, the solvable problem size

*Saying that a problem is intractable with an exponential complexity implies that the best parallel algorithm cannot have a polynomial complexity with a polynomial number of processors. Supposing this is false, a serial simulation of this parallel algorithm can solve the problem in polynomial time, hence contradicting the fact that the problem has an exponential complexity.

Combinatorial Search Problems

TD Snyder



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