Progress report submitted

in partial fulfillment of the requirement for

CENG 505 - Parallel Computing I

**PARALLEL COMPUTING**

**for**

**SCHEDULING ALGORITHMS**

By

Atıl KURT 200972008

Fall 2010

FALL 2008

Çankaya University

Department of Industrial Engineering

Spring 2007



**TABLE OF CONTENTS**

[1. INTRODUCTION 1](#_Toc283305232)

[2. SCHEDULING PROBLEMS 2](#_Toc283305233)

[3. OPTIMUM ALGORITHMS 4](#_Toc283305234)

[3.1 Special Algorithms 4](#_Toc283305235)

[3.2 Mathematical Model Solution Algorithms. 4](#_Toc283305236)

[4. HEURISTIC ALGORITHMS 6](#_Toc283305237)

[4.1 Metaheuristics 6](#_Toc283305238)

[4.1.1 Genetic Algorithm 6](#_Toc283305239)

[4.1.2 Simulated Annealing 8](#_Toc283305240)

[4.1.3 Tabu Search 9](#_Toc283305241)

[4.1.4 Ant Colony Optimization 9](#_Toc283305242)

[5. SCHEDULING FOR PARALLEL PROCESSING 11](#_Toc283305243)

[6. CONCLUSION 12](#_Toc283305244)

[REFERENCES 13](#_Toc283305245)

# INTRODUCTION

Parallel computing for the scheduling algorithms are discussed in this report. There are lots of scheduling problems, these problems can be solved by mathematical model techniques; but they include a lot of binary variables. So, solving big problems by using mathematical model techniques is hard due to computation times and capabilities of computers. In order to solve these problems, some heuristic and exact solution algorithms are developed. Parallel Computing can be applicable for these scheduling algorithms.

This report is such a literature survey of parallel computing for scheduling algorithms. Firstly, Scheduling problems will be explained. Then, some exact solutions and some heuristic algorithms will be explained and some articles will be given for these algorithms. Scheduling algorithms can also be used for parallel computing. Some literature works for scheduling algorithms for parallel computing will be given and discussed. Finally, parallel computing applicability about my thesis will be mentioned in this report.

# SCHEDULING PROBLEMS

Scheduling is a planning activity; it establishes the timing of the use of equipment, facilities and human activities. Aim of scheduling is increasing the resources efficiency to achieve its own objective. Generally scheduling algorithms are described about the machine and job environment. Machine is used for the resources and jobs are used for the activities. Generally scheduling includes the following activities.

* Assignment: Jobs are assigned to machines for the multi machine problems, scheduling problems are interest best assignment of jobs to machines.
* Sequencing: Ordering the jobs according to its objective.

In the literature, scheduling problems are shown by *α/β/γ* representation.

* + *α*: Machine environment
  + *β*: Task system
  + *γ:* Optimality criterion

Scheduling problems are summarized in the following table according to its representation. Each scheduling problem have to have *α* and *γ* representation; but some problems may not have the *β* representation. The *β* reprenestion field of these problem is shown by empty.

Table 1 Scheduling problems

|  |  |  |
| --- | --- | --- |
| **α** | **β** | ***γ*** |
| *1* – Single machine  *P* – Parallel machine  *Q* – Uniform parallel machine  *R* – Unrelated parallel machine  *F* – Flow shop  *O* – Open shop  *J* – job shop | *Pmtn* – Preemptive  *Chain* – Precedence constraint  *NR* – Non resumable  *rj –* ready times  *Tool-change*  Eligibility  Deterioting | *Cmax* – Maximum completion time  *Lmax* – Maximum lateness  *∑Cj* – Total completion time  *∑Tj* – Total tardiness  *∑uj* – Total tardy jobs  *∑wjCj* – Weighted completion times |

The followings are the some example scheduling problems and their *α/β/γ* representation.

* *P/tool-change /Cmax*: Makespan minimization problem on parallel machines with tool change constraints.
* *J/ /Cmax*: Makespan minimization problem on Job shop machine environment.
* *P/ rj /∑Tj*: Online total tardiness minimization problem for the parallel machines.

These problems solved by the mathematical models solution methods. These problems are generally NP-Hard problems. So, these problems cannot be solved in an applicable time. In order to solve these problems, some optimal and heuristic algorithms are developed.

# OPTIMUM ALGORITHMS

Optimum scheduling algorithms can be classified by their usage problems. Firstly some algorithms can be named as special algorithms. These algorithms are found by someone for the specific problems. Another optimum algorithm types are the mathematical model solution algorithms. These algorithms can be applied to each scheduling problems. In the following, these types of algorithms will be shortly described.

## Special Algorithms

These algorithms are used for only one problem types. Application of these algorithms for the specific problem gives the best solution. If these algorithms applied to other problems, the optimum solution will not be found. But these algorithms can be used to find heuristic solution for the other problems. Some special algorithm names and their problems are as follows:

* Shortest processing time (SPT): This algorithm gives optimum solution for the total completion time minimization problem for single and parallel machine environment (1//*∑Cj* andP//*∑Cj*).
* Earliest Due Date (EDD): This algorithm is used to solve minimization of maximum lateness for single machine problems (1//*Lmax*).
* Moore Algorithm. This algorithm is found by J.M Moore in 1968 to solve the minimization the total number of tardy jobs for the single machines (1//*∑uj*).

These algorithms are simple algorithms and solution of these is easy. But some special algorithms in literature are not easy to solve. So parallel computing can be used to solve these problems.

## Mathematical Model Solution Algorithms

Mathematical model is a tool to solve the real life problems. Scheduling problems can be solved by using the mathematical model. Algorithms are developed to solve these mathematical problems. Simplex algorithm and Branch and Bound (B&B) algorithm are well known algorithm to solve the mathematical model. Parallel computing can be used to solve these problems. In the following I will give an example about parallel computing application for the B&B algorithms. This following paper is an example of parallel computing application of the B&B algorithm in scheduling problem

* Kouiki, S., Jemni, M. Ladhari, T., 2010, Design of parallel distributed algorithm for the permutation flow shop.

In this article, the following table is obtained after applying the parallel computing to B&B algorithm for the above problem. Table shows the solution times for Tail092 and Tail098 problems according to processor number.

Table 2. Example run times for B&B algorithm

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Processor** | **1** | **2** | **4** | **6** |
| Tail092 | 2560 | 1400 | 750 | 560 |
| Tail098 | 15050 | 6940 | 3860 | 2870 |

CPU time reduce with the increasing number of processor. So, parallel computing can be used for the B&B algorithms.

# HEURISTIC ALGORITHMS

Heuristic scheduling algorithms are solution tools; they do not have to give optimum solution. But it is expected their solution must be near to optimum solution. Heuristic algorithms can be discussed in two classes. Firstly, the special algorithms are found by someone to solve specific problems. Another is the metaheuristics that can be used for each problem. Some examples for the special heuristics are as follows.

* LPT list algorithms 🡪Makespan minimization for parallel machines(*P//Cmax*)
* CDS heuristic 🡪 Makespan minimization for the flow shop machine environment (*F//Cmax*)*.*

## Metaheuristics

Metaheuristics are named as local search methods. It is top-level general strategy which guides other heuristics to search for feasible solutions in domains where the task is hard. These Heuristics generally use the natural life. There are a lot of metaheuristic techniques; these can be applied to scheduling algorithms. But, only the following four Metaheuristics will be discussed for the applicability of the parallel computing.

* Genetic Algorithm
* Simulated Annealing
* Tabu search
* Ant Colony optimiziation

### Genetic Algorithm

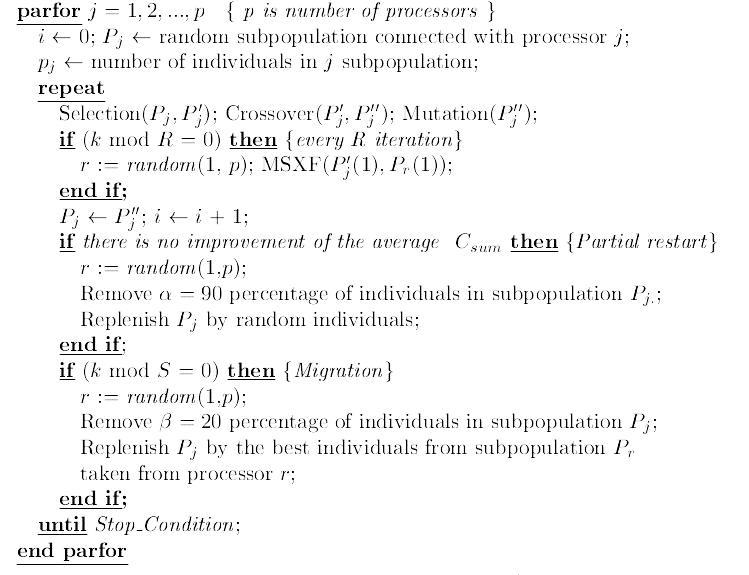
This algorithm mimics the process of natural selection. The Genetic algorithm can be used for the optimization problems. Also it can be applied to each scheduling problem. The Genetic algorithm is generally as follows:

* + 1. Randomly generate an initial population *M(0).*
    2. Compute and save the fitness *u(m)* for each individual m in the current population *M(t).*
    3. Define selection probabilities *p(m)* for each individual *m* in *M(t)* so that *p(m)* is proportional to *u(m).*
    4. Generate *M(t+1)* by probabilistically selecting individuals from *M(t)* to produce offspring via genetic operators.
    5. Repeat step 2 until satisfying solution is obtained.

Parallel computing can be applied to Genetic algorithms. Some examples about the Parallel computing application in literature are given below:

* Wang, N.,(2004) A parallel computing application of the genetic algorithm for lubrication optimization. Tribology Letters, Vol. 18.
* Alba, E., Troye J. M., A survey of parallel distributed genetic algorithms.
* Bozejko, W. Wodecki, M., Parallel genetic algorithm for the flow shop scheduling problems.

A parallel genetic algorithm from the Bozejko’s article is given below: four processor was used in this work and it compared with one processor solution times in the article. They have applicable times when they use parallel computing.



### Simulated Annealing

The search strategy of Simulated Annealing is analogy of solid thermodynamic state evaluation simulation. The general Simulated Annealling algorithm is described below:

“The procedure for increasing and reducing parameter *t* is specific for the implementation, and is called a *cooling schedule*. Cooling schedules frequently comprise the following steps.

* Initially temperature *t* should be big enough to allow visiting all feasible solutions.
* *t* is being increased until certain number of moves, or fraction of moves, is accepted.
* the temperature starts decreasing. At every temperature level thermodynamic equilibrium should be achieved. This is guaranteed if a certain number of moves are accepted.
* For low temperatures, the number of try moves may be very big to attain a determined number of accepted moves. Therefore, also an upper limit on the total number of moves at each temperature stage may be imposed.”

Simulated annealing algorithm can be solved for the scheduling problems and parallel computing can be applied to this heuristic. Some example about these applications are given in the following article.

* Czech ,J.Z., Czarnas, P. Parallel simulated annealing for the vehicle routing problem with time windows
* Barry, D. A., Morris, J., Parallel simulated annealing using CILK language: Aplication in estimating transport parameters for groundwater contaminants

### Tabu Search

Tabu search Uses a strategy of proccessing in the direction of biggest decrease or the smallest increase, of the objective function. The algorithm generally follows the following steps:

* Tabu search starts from some initial solution *x0*
* Analyzes its neighborhood *S(x0).*
* The best neighbor *x1*€ 2 *S(x0)* is selected as the next point to be visited.
* Analogously, for solution *xi* the best solution in neighborhood *S(xi )* is selected as the next solution *xi+1.*

Also Tabu search algorithms can be used all the optimization problem and scheduling problems. Some parallel computing application about the Tabu search in the literature is given below:

* Gendreau, M., laporte, G., Semet, F. (2000). A dynamic model and parallel tabu search heuristic for real-time ambulance relocation.
* Yi, H.,Yuhui, Q., Guangyuan, L., Kaiyou, L.,(2003). A parallel tabu search approach based on genetic crossover operation.
* Craınıc, T. G., Gendreau M., Potvin ,J., Parallel tabu search

### Ant Colony Optimization

Ant colony optimization seeks to mimic an ant's apparent ability to find the shortest distance between two points.

Ant colony optimization can be used to solve all scheduling problems. In the literature, there is a lot of parallel application about this algorithm. Some of them are as follows:

* Randall, M., A parallel implementation of Ant Colony Optimization.
* Delisle, P., Krajecki, M., Gravel, M., Gagné, C., Parallel implementation of an Ant Colony Optimization metaheurıstıc with OPENMP.

Execution time versus the processor graph from the Delisle’s article is given in the following figure. It is easily seen that increasing number of processor solves problem fast. So, the parallel computing for the Ant Colony optimization technique is applicable.

Figure 1 Execution time versus number of processor graph

# SCHEDULING FOR PARALLEL PROCESSING

Parallel processing is used for scheduling algorithms. Also scheduling algorithms are used for the parallel computing. Scheduling algorithms will increase the efficiency of processors. This will result the reduction in CPU times with load balancing. Processor are used as an machine and tasks are used as job. The following problems can be given as examples for the scheduling for parallel processing.

* *P//Cmax:* Processors are identical and the load balancing is wanted in these processors.
* *R//Cmax:* Processors are not identical and the load balancing is wanted.

There are articles and publications about the scheduling for parallel computing. The following book gives more details about the scheduling for the parallel processing.

* Drozdowski, M.(2009) Scheduling For Parallel Processing. Computer Communications and Network.

# CONCLUSION

This report is written to analyze the applicability of parallel computing on scheduling problems. Some examples in literature about exact solution algorithms are and their parallel computing applications are given. Also Scheduling algorithms can be used for the parallel computing.

Parallel Computing can be used in the scheduling problem and its solution algorithms. My thesis is a scheduling problem. I can use the above solution tools. If my run times are huge, then I can easily apply these parallel computing to these algorithms to solve my problem.

# REFERENCES

* 1. Kouiki, S., Jemni, M. Ladhari, T., 2010, Design of parallel distributed algorithm for the permutation flow shop.
  2. Wang, N.,(2004) A parallel computing application of the genetic algorithm for lubrication optimization. Tribology Letters, Vol. 18.
  3. Alba, E., Troye J. M., A survey of parallel distributed genetic algorithms.
  4. Bozejko, W. Wodecki, M., Parallel genetic algorithm for the flow shop scheduling problems.
  5. Czech ,J.Z., Czarnas, P. Parallel simulated annealing for the vehicle routing problem with time windows
  6. Barry, D. A., Morris, J., Parallel simulated annealing using CILK language: Aplication in estimating transport parameters for groundwater contaminants
  7. Gendreau, M., laporte, G., Semet, F. (2000). A dynamic model and parallel tabu search heuristic for real-time ambulance relocation.
  8. Yi, H.,Yuhui, Q., Guangyuan, L., Kaiyou, L.,(2003). A parallel tabu search approach based on genetic crossover operation.
  9. Craınıc, T. G., Gendreau M., Potvin ,J., Parallel tabu search
  10. Drozdowski, M.(2009) Scheduling For Parallel Processing. Computer Communications and Network.
  11. Randall, M., A parallel implementation of Ant Colony Optimization.
  12. Delisle, P., Krajecki, M., Gravel, M., Gagné, C., Parallel implementation of an Ant Colony Optimization metaheurıstıc with OPENMP.