Review of Task Scheduling Algorithms Using Genetic Approach

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***Abstract*- The aim of scheduling problem in multiprocessors is to find the optimal or nearly optimal solution for the assignment of multiple tasks to multiple processors so as the minimum completion time can be achieved. The efficiency of any scheduling approach depends upon the problem formulation and the performance characteristics of the algorithm used for the purpose. The scheduling algorithm studied in this paper is Genetic Algorithm (GA) and various variants of genetic algorithm used for task scheduling proposed by various researchers over the period of time. The introduction and efficiency of various variants using the different performance parameters is compared.**

Keywords— Task Scheduling, Genetic Algorithm, Heuristic Algorithm, Performance Analysis, makespan, flowtime, crossover, mutation

I. Introduction

The Task Scheduling is one of the most critical issue in planning, managing and completion of the successful parallel programs. We can achieve the maximum efficiency of system, only if task assignment and scheduling methods are effective. Task assignment problem is well defined NP Complete problem which is one of the most challenging problem and field of study for many researchers in parallel computing [1]. There are several approaches for the task assignment in the form of theoretical graphs, integer programming and heuristic model. Directed Acyclic Graph (DAG) is one of the method that is used for the collection of the tasks that has to be scheduled and thus it sets the precedence for tasks onto the system [2]. The tasks are assigned in such a way that no single processor will remain idle for long time and vice versa i.e. no maximum or extra load onto a single processor. If the number of tasks and processors are high, then finding the optimal solution using DAG or other traditional algorithms (FCFS, RR, and LCS) would be time consuming and expensive [3]. Therefore heuristic algorithms which are based on the problem condition are the best approach for the problems like task assignment. Heuristic is best approach scheduling because it prevent the common and popular errors in their own execution process while trying to find the optimal solution.

There are many heuristic approaches till date which are used for the task assignment on the multiprocessors. One of the best approach is the Genetic Algorithm (GA) which is based on the Darwinian theory of evolution [4]. Thus genetic algorithms implement the optimization strategies by simulating evolution of species through natural selection. There are many researchers who works in this particular field of Computer Science. We will discuss the work done so far on the task assignment using genetic algorithms, parameters used and performance analysis by various researchers.

The rest of the paper is organized as follows: section II contains operators and parameters used for evaluation of genetic algorithm, Section III explains task scheduling algorithms based on genetic algorithm before the conclusion of paper in last section.

II. Operators and Parameters used For Evalution of Genetic Algorithm (GA)

After the introduction, here the discussion is done on the operators and parameters used for evaluation of genetic algorithm.

A. Crossover operator [5]

Crossover operator is used to differ the analogy of chromosomes from one generation to another. There are various techniques for crossover :

- One Point Crossover
- Two Point Crossover
- Three Parent Crossover
- Uniform Crossover
- Half Uniform Crossover
- Cut and Splice

We will discuss later that which crossover technique is used in particular algorithms mentioned.

B. Mutation operator [5]:

Mutation mainly means the change in the genetic structure of the chromosome. It is used to maintain the diversity among generations so that there won't be the dead till the optimal solution or solution close to optimal is found. There are various mutation operator techniques:

- Flip Bit mutation

- Boundary mutation
- Uniform mutation
- Non Uniform mutation
- Gaussian mutation

C. *Selection operator [15]*

It is the operator which is used for the selection of chromosomes which are used for crossover. A typical selection method is to select all the individuals in the population to be the N parents, to mutate each parent to form N offspring, and to probabilistically select, based upon fitness, N survivors from the total 2N individuals to form the next generation.

D. *Crossover probability [15]*

The basic parameter in crossover technique is the crossover probability (Pc). Crossover probability is a parameter to describe how often crossover will be performed. If there is no crossover, offspring are exact copies of parents. If there is crossover, offspring are made from parts of both parent's chromosome. If crossover probability is 100%, then all offspring are made by crossover. If it is 0%, whole new generation is made from exact copies of chromosomes from old population (but this does not mean that the new generation is the same!).

E. *Population [15]*

A population is collection of individuals. The two important aspects used in GA are :

- The initial population generation.
- The population size.

F. *Mutation probability [15]:*

The important parameter in the mutation technique is the mutation probability (Pm). The mutation probability decides how often parts of chromosome will be mutated. If there is no mutation, offspring are generated immediately after crossover (or directly copied) without any change. If mutation is performed, one or more parts of a chromosome are changed. If mutation probability is 100%, whole chromosome is changed, if it is 0%, nothing is changed.

G. *Fitness Value [5]*

As we know that task assignment is the multi objective problem. To evaluate these types of problems there are many optimization criteria. The basic is **makespan:** It is the time when the latest job is finished. It must be minimum. The other is **flowtime:** It is the sum of finalization times of all the jobs. It should also be minimum. The fitness value of any algorithm is calculated in terms of makespan and flowtime. The efficiency or performance can also be determined from these two factors.

III. TASK SCHEDULING ALGORITHMS BASED ON GENETIC ALGORITHM

Here the discussion is done on task scheduling algorithms based on genetic algorithm

A. *Heuristic based Genetic Algorithm (HGA) [7]*

In this paper the problem of same execution time or completion time and same precedence in the homogeneous parallel system is resolved by using concept of Bottom-level (b-level) or Top-level (t-level). This combined approach named as heuristics based genetic algorithm (HGA) based on MET (Minimum execution time)/Min-Min heuristics and b-level or t-level precedence resolution and is compared with a pure genetic algorithm, min-min heuristic, MET heuristic and First Come First Serve (FCFS) approach. Results of the experiments show that the heuristics based genetic algorithm produces much better results in terms of quality of solutions.

B. *The Critical Path Genetic Algorithm (CPGA) [8]*

CPGA algorithm is considered a hybrid of GA principles and heuristic principles (e.g., given priority of the nodes according to ALAP level). On the other hand, the same principles and operators which are used in the SGA algorithm have been used in the CPGA algorithm. The encoding of the chromosome is the same as in SGA, but in the initial population the second part(schedule) of the chromosome can be constructed using one of the following ways:

- The schedule part is constructed randomly as in SGA.
- The schedule part is constructed using ALAP.

C. *Task List (TL), Processor List (PL), and combination of both (TLPLC) [9]*

The hybrid approach composed of GA and MLSH (Modified List Scheduling Heuristic). Genetic algorithms try to mimic the natural evolution process and generally start with an initial population of chromosomes, which can either be generated randomly or based on some other algorithms. Here, the initial population has started based on MLSH. Three different types of chromosomes (TL, PL, and TLPLC) are developed to generate the genetic chromosome. In each generation, the population goes through the processes of fitness evaluation, selection, crossover and mutation.

D. *An Adaptive Genetic Algorithm (AGA) [10]*

In this paper author solve the task assignment problem with considering load balancing by new method, based on the genetic (GAs) algorithms. GA employs a repair function to guarantee valid assignments during the process of algorithm. According to the effectiveness of this algorithm in comparison with heuristic algorithms including branch and bound and graph cuts, it can be used for task assignment problem in most parallel processing environments.

E. *Performance Effective Genetic Algorithm (PEGA) [11]*

This study proposes a genetic based approach to schedule parallel tasks on heterogeneous parallel multiprocessor system. The scheduling problem considered in this study includes - next to search for an optimal mapping of the task and their sequence of execution and also search for an optimal configuration of the parallel system. An approach for the simultaneous optimization of all these three components of scheduling method using genetic algorithm is presented and its performance is evaluated in comparison with the First Come First Serve (FCFS), Shortest Job First (SJF), Round Robin (RR), Priority and Largest Job First (LJF) scheduling methods.

F. Improved Genetic Algorithm (IGA) [12]

This paper presents an improved Genetic Algorithm (IGA) based approach for the single mode resource constrained project scheduling problem (RCPSP) with makespan minimization as objective. The proposed approach uses binary string based representations and operators for chromosomes. The approach was tested on some difficult instances with high optimality gap in the J120 data set of PSPLIB. It was found that the proposed approaches gave better results as compared to activity list based representations that are commonly used.

G. Task Scheduling Distributed System Simulated Annealing (TSGASA) [13]

In this paper, a new genetic algorithm, named TDGASA, is presented which its running time depends on the number of tasks in the scheduling problem. Then, the computation time of TDGASA to find a sub-optimal schedule is improved by Simulated Annealing (SA). The results show that the computation time of the proposed algorithm decreases compared to an existing GA-based algorithm, although, the completion time of the final scheduled task in the system decreases a little.

H. Scheduling multiprocessor tasks with genetic algorithms (SMTGA) [14]

In this paper, an efficient method based on genetic algorithms is developed to solve the multiprocessor scheduling problem. To efficiently execute programs in parallel on multiprocessor scheduling problem must be solved to determine the assignment of tasks to the processors and the execution order of the tasks so that the execution time is minimized. Even when the target processors are fully connected and no communication delay is considered among tasks in the task graph the scheduling problem is NP-complete. This is one of the first algorithm proposed on task scheduling using the genetic algorithms.

IV. CONCLUSION

Task Scheduling or assignment in multiprocessors if NP Hard problem. As discussed the heuristic algorithms which obtain the close optimal or sub optimal solution are preferred over the traditional algorithms which either follows the First Come First Serve criteria or other array based criteria or mainly dynamic programming, backtracking or greedy methods.

Among heuristic algorithms, genetic algorithms (GA) are considered as one of the best approach because of its quick adaptation with the problem or set of problems. Also when experimentally examined the completion time, makespan and flowtime of these algorithms are minimum among other algorithms. The results are categorized in form of tables given below:

TABLE I. COMPARISON BETWEEN TYPES OF CROSSOVER AND MUTATION OPERATORS USED IN DIFFERENT ALGORITHMS

Algorithms	Crossover operator used	Mutation operator used
HGA	One Point crossover and two Point Crossover	Swapping
CPPGA	Two Point crossover	Randomly
TLPLC	Single point crossover	Non Uniform
AGA	Two Point Crossover	Randomly
PEGA	Random selection	Swapping
IGA	Pair of adjacent parents	Binary
TSGASA	Random Selection	Randomly
SMTGA	Higher fitness value precedence	Randomly

TABLE II. COMPARISON BETWEEN TYPES OF CROSSOVER PROBABILITY AND MUTATION PROBABILITY

Algorithms	Crossover probability	Mutation probability
HGA	0.6	0.9
CPPGA	0.8	0.02
TLPLC	0.7	0.3
AGA	0.7	0.3
PEGA	0.6	0.8
IGA	0.95	0.95
TSGASA	0.6	1.1
SMTGA	0.5	0.4

TABLE III. COMPARISON BETWEEN MAKESPAN, FLOWTIME AND PERFORMANCE OF DIFFERENT TASK SCHEDULING GENETIC ALGORITHM

Algorithms	Makespan	Flowtime	Efficiency
HGA	14	79	71.4
CPPGA	14.33	81	71
TLPLC	14	80	71.43
AGA	18	90	65
PEGA	21	91	62.5
IGA	15	88	68
TSGASA	14	80	71
SMTGA	24	111	42.7

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