Journal of Innovative Engineering and Research (JIER)
Vol.- 3,Issue - 2,October 2020, pp. 30-32 (3 pages)

Analysis of Tree Based Graph Coloring Algorithm and Hierarchical Parallel Genetic Algorithm for Graph Coloring Problem

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Abstract— Graph coloring is one of the finest known, trendy and broadly used study area in the field of graph theory, having several applications and assumptions, which are continuously revised by various computer scientists all along the world. This paper discusses the importance and performance comparison of Tree Based Graph Coloring Algorithm (TGCA) and Hierarchical Parallel Genetic Algorithm for Graph Coloring Problem (HPGAGCP) of Graph theory using DIAMAC. In this paper we also have illustrated experimental results of different DIMACS graph instances.

Index Terms— Graph coloring problem, Register allocation, Register Interference Graph, chromatic number.

I. INTRODUCTION

Efficiency for any computer program is calculated by two factors. One is time complexity and another next one is space complexity. Optimization techniques are used to reduce the execution time of any program. On the same way CUP registers are used to reduce the execution time of programs. CUP registers are fast memory but they are in limited numbers. So to get better performance of algorithm, runtime compiler must have an efficient register allocation algorithm [2].

Most computer system has a set of registers, dedicated memory location that can be accessed quickly, can have computation performed on them and they are small in quantity. Variables are the basic storage unit in many programming language. Value of variables is stored in either main memory or in the CPU registers. Main memory is large in size then CPU registers, but it is slow in speed. So program required CPU registers to speed up the program execution. Processor can quickly read and write values in CPU registers at the time of program execution. But CPU registers are limited in most of the CPUs. So it is difficult to allot registers to all variables of program.

Register allocation (RA) is an important part of compiler design. It is a part of code generation phase of compiler.

II. REGISTER ALLOCATION USING GRAPH COLORING [2]

This section included some important terminologies related to register allocation algorithm using graph coloring (GC) and general procedure of register allocation using GC [3] is also included in this section.

1.1 Basic Terminologies

1 Temporary variables: - These variables are used in programs to perform any mathematical and logical operation in programs. Generally these variables get space in main memory. But to speed up the variable access, CPU registers are allocated to those variables.

2 Variable Live Range: - Every variable is considered in live range at point in program where variable is lives.

3 Variable Live Interval: - Compiler convert the source code into intermediate representation code (IR Code). Live range for a variable is smallest sub-range of the IR Code.

4 Register Interference Graph (RIG):- It is a undirected graph in which all vertices represents the variables and connecting edges represents live status of variables at the same program point.

III. TREE BASED GRAPH COLORING ALGORITHM (GCA)

A graph coloring is a projection of tags, called colors, to the vertices of a graph. Distribution of colors in that manner such no two adjacent vertices contribute to the same color. The chromatic number graph G*G* is the minimum number of colors by which such assignment is possible. Thus the fewest number of colors essential to color a graph *G* is known as its chromatic number.

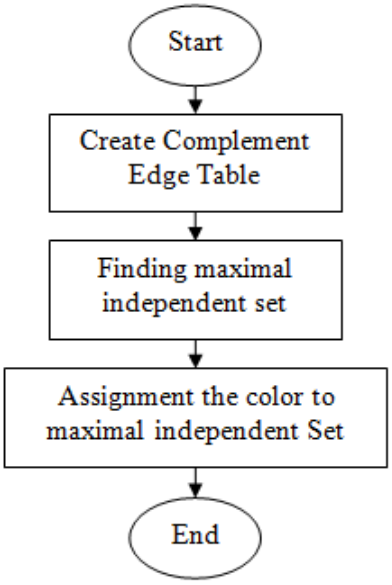

Figure 1: Basic Steps of Tree Based GCA

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Vol.- 3,Issue - 2,October 2020, pp. 30-32 (3 pages)

This section exploring graph coloring algorithm used to implement proposed register allocation algorithm. A tree data structure based GCA is used to implement register allocation algorithm. The entire process of graph coloring is divided into three basic steps.

Solving the graph coloring problem is NP-hard [1] and it is hard to determine time complexity of algorithm. But by the experimental results and hypothesis the worst case complexity of selected algorithm is O(2n-1) [5]. Time complexity to find maximal independent set is always O ($2^{\log n}$) [7]. Selected algorithm gives high performance for high degree graphs i.e. this algorithm is more suitable for the programs where number of variables are high and live intervals of variables in program at same time are also high.

IV. TREE BASED GRAPH COLORING ALGORITHM EXPERIMENTAL RESULTS

Tree based graph coloring algorithm is a base algorithm for this proposed register allocation algorithm. In this research we have also tested this base algorithm implementation using java programming language. Table 1.1 shows the experimental results of different DIMACS graph instances. Table 1.1 contains information about vertices and edges in graph, average degree of vertices in graph is also there. Chromatic number and execution time is calculated through graph coloring algorithm. Total 11 graph instances experimental details are shown in table 1. Figure 1 shows the graph representation of degree of vertices and chromatic number of different graph instances.

S.No	Instance	No. of Vertices	No. of Edges	Average Degree	Chromatic No. (K)	Execution Time (in Sec.)
1	myciel3	11	20	3.64	4	0.02
2	1-FullIns_3	30	100	6.67	4	0.83
3	2-nsertions_3	37	72	3.89	4	53.16
4	GEOM20b	20	52	5.20	4	0.11
5	queen5_5	25	320	25.60	5	0.06
6	myciel4	23	71	6.17	5	0.09
7	GEOM20	20	40	4.00	5	0.22
8	GEOM20a	20	57	5.70	5	0.078
9	GEOM30b	30	111	7.40	5	0.063
10	myciel5	47	236	10.04	6	39.43
11	GEOM30	30	80	5.33	6	4.015

Table 1: Tree Based Graph Coloring Algorithm Experimental Results

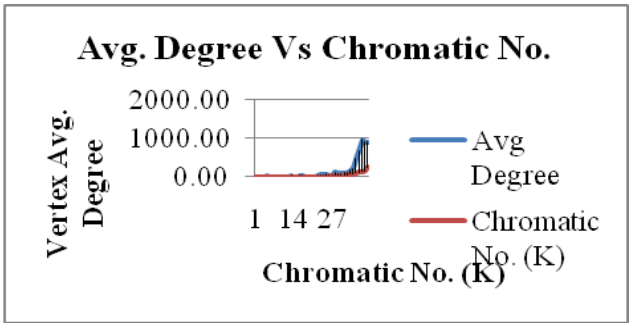

Figure 2: TGCA Experimental Results Graph (Average Degree Vs Chromatics Number)

V. TGCA RESULTS COMPARISON WITH OTHER ALGORITHMS

This section covers result comparison of base algorithm with two other graph coloring algorithms [5].

5.1 TGCA Vs HPGAGCP

Instance	K(TGCA)	K (HPGAGCP)
myciel3	4	4
myciel4	5	5
queen5_5	5	5
queen6_6	10	8
myciel5	6	6
queen7_7	7	8
queen8_8	10	10
miles1000	45	42

Table 2: TGCA Vs HPGAGCP

In table 2 TGCA generated chromatic numbers are compared with HPGAGCP generated chromatic numbers by Hindi et al. (2012) [4]. By the results analysis it has been observed that for some graph instances like queen6_6 and miles1000, TGCA is giving optimum chromatic number. Figure 3 shows the graphical comparison of TGCA and HPGAGCP.

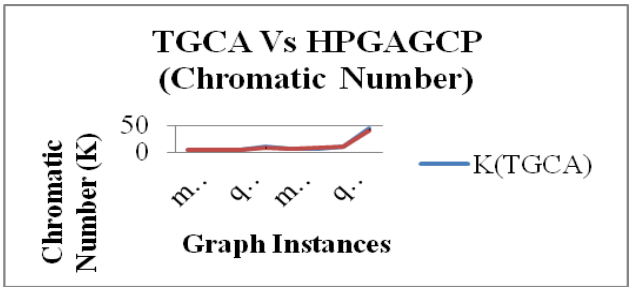

Figure 3: TGCA Vs HPGAGCP (Chromatic Number)

VI. CONCLUSION

Tree based graph coloring algorithm works efficient for high degree graphs. This algorithm uses the special type of tree data structure for generating the graph coloring combinations. We have compared the tree based graph coloring algorithm

results with well know graph coloring algorithms, that is hierarchical parallel genetic algorithm for graph coloring problem (HPGAGCP).

This approach can be used in case of un-sufficient register availability. It gives maximal utilization of CPU registers and improves the execution time by allotting registers to those variables which has long live interval time. After a fair assessment we found that Graph coloring is much more helpful to compiler optimization as it has capacity to raise the compiler performance and utilization.

As a result we conclude that the A Tree Based Register Allocation Algorithm using Graph Coloring Approach is proficient, finest time complex, large dataset sustained and extensive area of application supported algorithm.

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