**ASSIGNMENT 2 Matrix multiplication using Block methods in Open MP and Java multithreading and multicore**

**Declaration**

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| Programme | MSc. In computing (secure software engineering) |
| Module Code | CA670 |
| Assignment title | Assignment 2 - Java Threads vs. OpenMP - Matrix Multiplication |
| Submission Date | 28/03/2022 |
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I have read and understood the referencing guidelines found recommended in the assignment guidelines.

Name: Vikrant Singh Date: 28/03/2022

**Introduction**

In both program the matrix multiplication method used is blocked method which is basically we divide large matrix into small submatrices, and it is a divided and conquer approach and our goal is to maximize accesses to the data loaded into the cache before data got replaced.

A picture containing shoji

Description automatically generated

This figure [2] above shows the array access pattern with native approach where white colour blocks mean not yet accessed, light colour blocks mean older accesses, and dark colour blocks means newer accesses

A picture containing shoji, crossword puzzle, building

Description automatically generated

This figure [2] above shows the accessed pattern of array with blocked method and we can see that a smaller number of elements are accessed.

**Program Description**

**Open MP Program**

1. **Function 1**

random\_square\_matrix(int dimension)

This function used to generate random square matrix for given dimension from varying from 200 to 2000 with increment of 200.

1. **Function 2**

zero\_square\_matrix (int dimension)

This function is used to create a matrix of same dimension as in above function, but this is empty matrix to store results.

1. **Function 3**

double ParallelWithPragma(NEW\_TYPE\*\* matrix\_A, NEW\_TYPE\*\* matrix\_B, NEW\_TYPE\*\* matrix\_C, int size)

This function is like heart of the program and holds the #pragma functionality of OpenMP using following code

 #pragma omp parallel shared(matrix\_A, matrix\_B, matrix\_C, size, chunk) private(i, j, k, jj, kk, thread\_no, tmp)

And it shares the variable specified in private for creating multiple instances of for loop with thread and each instance have its own private set of variables.

#pragma omp for schedule (static, chunk)

And the scheduling is used with static option with chunk size of 2 to schedule iteration of loop and the algorithm for matrix multiplication is there and then calculate total task completion time in seconds.

1. **Function 4**

void matrix\_dimension(int dimension)

This function contains output functionality and call the above function to get the results and print them on console.

1. **Function 5**

int main(int argc, char\* argv[])

Main contains loop which provide dimensions to *matrix\_dimension*(*int dimension)* function to create different size matrices.

**Output**

For output I use my laptop which has i5 5th generation processor with only 4 cores and Cygwin which helps me un gcc on windows for open MP compilation.

Text

Description automatically generated with medium confidence

A picture containing timeline

Description automatically generated

**Java Program with multithreading and multicore**

1. **Class 1**

**public** **class** MatrixMultiplicationParallel{}

ExecutorServiceexecutor=Executors.*newFixedThreadPool*(Runtime.*getRuntime*().availableProcessors());

executor.execute(**new** Block\_matrix\_multiply(matrixA, matrixB, result, dimension));

executor.shutdown();

This class contains multicore functionality using Executer as follows and initialize matrices required and create different dimension for different matrices with increment of 200 each with iteration.

1. **Class 2**

**public** **class** Matrix\_generator{}

This class creates matrices with different dimensions with random values and return the resulted matrix for multiplication.

1. **Class 3**

**public** **class** Block\_matrix\_multiply **implements** Runnable{}

This class is runnable so to make it multithreaded and contain blocked matrix multiplication algorithm which is exact same we are using with open MP.

**Output**

This program is made in Eclipse and run in Eclipse also using same laptop which has i5 5th generation processor with only 4 cores.

Text

Description automatically generated

**Comparison of performance between two programs**

|  |  |  |
| --- | --- | --- |
| Size of matrix | Results in java Multithreaded and multicore(seconds) | Results with pragma in Open MP (seconds) |
| 200x200 | 0.070 | |  |  | | --- | --- | | 0.023999 |  | |
| 400x400 | 0.322 | |  | | --- | | 0.177599 | |
| 600x600 | 0.816 | |  | | --- | | 0.570467 | |
| 800x800 | 2.116 | |  | | --- | | 1.465169 | |
| 1000x1000 | 3.782 | |  | | --- | | 2.736900 | |
| 1200x1200 | 6.785 | |  | | --- | | 4.746159 | |
| 1400x1400 | 10.817 | |  | | --- | | 7.507706 | |
| 1600x1600 | 16.293 | 11.734908 |
| 1800x1800 | 23.749 | |  |  | | --- | --- | | 17.387102 |  | |
| 2000x2000 | 34.058 | |  | | --- | | 23.833347 | |

**Reference**

[1] A. Kalapgar, "Github," 19 April 2020. [Online]. Available: https://github.com/iarchanaa/Large\_Matrix\_Multiplication\_Using\_openMP. [Accessed 03 2022].

[2] J. L. H. a. D. A. Patterson, "chapter 2 Blocking," in *Computer Architecture A Quantitative Approach (5th edition)*.

[3] J. Corner, "OpenMP: Data-Sharing Rules," 27 June 2016. [Online]. Available: http://jakascorner.com/blog/2016/06/omp-data-sharing-attributes.html#:~:text=%23pragma%20omp%20parallel%20for%20shared(n%2C%20a)%20private,private%20variables%20is%20sometimes%20unintuitive.. [Accessed 03 2022].

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[5] Venkatesh, "Matrix Multiplication with Java Threads - Optimized Code (Parallel)," 22 January 2020. [Online]. Available: https://www.javaprogramto.com/2020/01/java-matrix-multiplication-threads.html. [Accessed 03 2022].