## Distributed and Parallel Computing

Assignment 1 - Performance Evaluation of single and multi-core implementations

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Licenciatura em Engenharia Informática e Computação

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17/03/2024

## Contents

1 Problem Description				
2	Alg	orithms	2	
	2.1	Simple Matrix Multiplication	2	
	2.2	Line Matrix Multiplication	2	
	2.3		3	
	2.4	Parallel Implementations of Line Matrix Multiplication	3	
3	Per	formance Metrics	4	
4	Res	sults and analysis	5	
	4.1	Comparing Normal and Line Multiplication Algorithms	5	
	4.2	Comparing Line and Block Multiplication Algorithms	5	
	4.3	Comparing Sequential and Parallel implementations of Line Mul-		
		tiplication	6	
5	Cor	nclusions	6	
6	Anı	nexes	7	
	6.1	Normal Multiplication (C) Measurements	7	
	6.2	Normal Multiplication (Java) Measurements	8	
	6.3	Line Multiplication (C) Measurements	10	
	6.4	Line Multiplication (Java) Measurements	12	
	6.5	Block Multiplication Measurements	14	
	6.6	Line Multiplication Parallel Implementation A Measurements	15	
	6.7	Line Multiplication Parallel Implementation B Measurements	17	

#### 1 Problem Description

In this analysis, we explored the impact of the memory hierarchy on processor performance during the processing of substantial data volumes, in a single and multi-core context. Our investigation employs matrix multiplication as a case study, a relevant computation prevalent across diverse domains, such as computer graphics or machine learning.

#### 2 Algorithms

In this project we used three distinct algorithms to evaluate the performance of a single processor when processing large data sets. Two parallel versions of one of these algorithms were implemented. These were the algorithms implemented:

#### 2.1 Simple Matrix Multiplication

In our initial setup, we were given a basic C/C++ algorithm for multiplying two matrices. This algorithm multiplies each row of the first matrix with every column of the second matrix to calculate the product. The computational complexity of this method is cubic, denoted as  $O(n^3)$ .

```
for (i = 0; i < m_ar; i++) {
    for (j = 0; j < m_br; j++) {
        temp = 0;
        for (k = 0; k < m_ar; k++) {
            temp += pha[i * m_ar + k] * phb[k * m_br + j];
        }
        phc[i * m_ar + j] = temp;
    }
}</pre>
```

#### 2.2 Line Matrix Multiplication

This variant introduces an enhanced algorithm for computing the matrix product by multiplying each element of the first matrix with the corresponding row in the second matrix. Despite these optimizations, the algorithm still maintains a cubic computational complexity of  $O(n^3)$ , reflecting the inherent challenge of reducing the computational demands of matrix multiplication without altering the fundamental approach.

```
for (i = 0; i < m_ar; i++) {
    for (k = 0; k < m_ar; k++) {
        for (j = 0; j < m_br; j++) {
            phc[i * m_ar + j] +=
            pha[i * m_ar + k] * phb[k * m_br + j];
        }</pre>
```

}

#### 2.3 Block Matrix Multiplication

In our latest adaptation, we have improved the matrix multiplication strategy by segmenting the matrices into sub-matrices or 'blocks'. These blocks are then processed independently before their results are consolidated. This technique, known as block matrix multiplication, operates under the same cubic time complexity,  $O(n^3)$ , as its predecessors. The primary innovation of this method lies in its potential to enhance memory access efficiency. This approach aims to increase the likelihood of faster data processing by working with smaller blocks of data at a time. The data being processed can reside in faster, lower-level cache memories (such as L1 and L2 caches) more frequently. This optimization reduces the latency associated with retrieving data from higher-level memory stores, theoretically improving overall execution speed by leveraging the hierarchical nature of memory systems for more efficient data access and computation.

#### 2.4 Parallel Implementations of Line Matrix Multiplication

Lastly, two different parallel versions of the Line Matrix Multiplication were implemented using OpenMP.

In this first implementation only the outer loop ( $i\ loop$ ) is parallelized, so each thread is responsible for handling a portion of those iterations, leaving the inner loops ( $k\ and\ j\ loops$ ) executing sequentially in each thread.

```
#pragma omp parallel for private(i, j, k)
    for (i = 0; i < m_ar; i++) {
        for (k = 0; k < m_ar; k++) {
            for (j = 0; j < m_br; j++) {</pre>
```

```
phc[i * m_ar + j] += pha[i * m_ar + k] * phb[k * m_br + j];
}
}
```

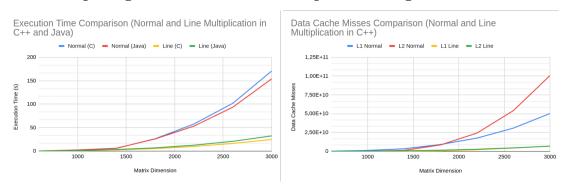
In this second version the loop being parallelized is the middle one (k loop). In each iteration if the top loop ( $i\ loop$ ), the work of computing the matrix is divided amongst threads based on the  $k\ loop$ .

#### 3 Performance Metrics

To measure the performance of algorithms developed in C/C++, we leveraged the Performance API (PAPI), which offers insights into a range of indicators concerning CPU efficiency and how the CPU cache memory is leveraged by the program. This comprehensive evaluation not only included the time taken by the algorithm to execute but also measured the frequency of cache misses at both L1 and L2 cache levels. By averaging these data points, we aimed to smooth out the small inconsistencies that might arise from each run, potentially influenced by the state of the computing environment. The C/C++ programs were compiled using the -O2 optimization flag, a step that significantly refines both the compilation process and the performance of the final executable. Furthermore, this study included a comparative assessment of the execution times for the algorithms when implemented in both C/C++ and Java, offering a dual perspective on their performance efficacy, as well as comparisons between sequential and parallel implementations of specific algorithms.

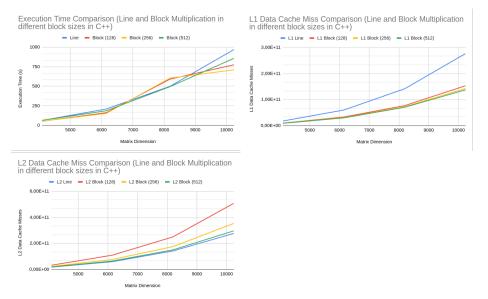
#### 4 Results and analysis

#### 4.1 Comparing Normal and Line Multiplication Algorithms



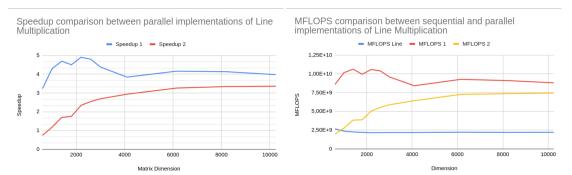
As we expected, the C++ and Java implementations of these algorithms have very similar execution times across all the matrices sizes tested. Also as expected, the line multiplication algorithm has a faster execution time and lower L1 and L2 cache misses, as instead of directly computing and assigning each element of the result matrix, it accumulates the results in the corresponding position of the result matrix, that allows for contiguous and more efficient access to the memory locations of the resulting matrix.

#### 4.2 Comparing Line and Block Multiplication Algorithms



When comparing the Line and Block Multiplication algorithms in different block sizes we recognized that while L1 cache misses tend to be significantly higher in the Line multiplication algorithm, L2 misses also tend to be slightly lower. This led to not very interesting results regarding the execution times, as for each matrix dimension the faster algorithm (or block size) varied. However, the 512 Block Size algorithm was consistently the alternative with less data cache misses.

## 4.3 Comparing Sequential and Parallel implementations of Line Multiplication



At last, we compared the sequential implementation of the Line Multiplication Algorithm to two parallel implementations. First measuring the speedup, the time of the sequential execution divided by the time of parallel execution. As expected, the speedups for both parallel algorithms were i1, meaning both of them were faster then the sequential alternative. The exception is the speedup of the second parallel implementation for smaller matrix dimensions, probably due to the overhead caused by creating multiple threads inside the inner k loop. For small matrices, this overhead caused by this is more costly then the parallelization is effective.

The first parallel implementation showed to be faster because it parallelized the outer loop, allowing each thread to work on different sections of the resulting matrix.

#### 5 Conclusions

This project showed us how memory accesses impact the efficiency of an algorithm. With proper implementation and memory manipulation, apparently similar algorithms can have significant execution times. We were also able to study parallelization, and how the different methods of doing it can affect the efficiency of the algorithms, considering the order of creating the threads and their overhead. Lastly, we learned about methods of performance analysis, using PAPI and comparing algorithms through different metrics.

## 6 Annexes

## 6.1 Normal Multiplication (C) Measurements

	Dimension	600			Dimension	1000	
	Time	L1	L2		Time	L1	L2
	0.27	244813494	40744559		2.049	1222059445	238066627
	0,268	244798294	40449564		2,474	1227462850	254528600
	0,277	244835569	42200261		2,424	1227483614	277796038
	0,271	244798351	39624506		2,583	1227931798	246159377
	0,271	244806456	41663199		2,303	1227477934	232967869
	0,278	244801925	40153630		2,246	1227471954	277467300
	0,200	244805558	40153030		2,282	1227547055	272923698
	0,273	244819900	41320483		2,295	1227460636	265301141
	0,272	244394764	42503690		2,262	1227400030	268354812
	0,293	244653151	41685950		2,202	1227433320	256915676
Average	0,2743	244752746,2	41130062,4	Average	2,3123	1226973402	259048113,8
Average			41130002,4	Average			2000-0110,0
	Dimension	1400			Dimension	1800	
	Time	L1	L2		Time	L1	L2
	5,82	3408529342	1248742888		26,277	9080293891	8532135607
	5,936	3429021317	1395997009		26,292	9090315029	8290440863
	5,912	3429193439	1349871911		26,151	9090415316	8010071361
	5,938	3428801714	1609801927		26,276	9090552704	8731271025
	5,906	3429022967	1210182977		26,316	9090198039	8830750213
	5,702	3428651558	1320733250		26,198	9090367622	8431537498
	5,695	3428712573	1269961870		26,341	9090225446	8494552580
	5,787	3428609799	1372045204		26,135	9090463735	8310259749
	5,828	3428612836	1228764765		26,259	9090579420	8849043835
	5,838	3428421480	1209824227		26,312	9090041055	8705363239
Augraga							
Average	5,8362	3426757703	1321592603	Average	26,2557	9089345226	8518542597
Average	5,8362 Dimension	3426757703 2200	1321592603	Average	26,2557 Dimension	9089345226 2600	8518542597
Average			1321592603 L2	Average	,		8518542597 L2
Average	Dimension	2200		Average	Dimension	2600	
Average	Dimension Time	2200 L1	L2	Average	Dimension Time	2600 L1	L2
Average	Dimension Time 55,962	2200 L1 17620532070	L2 24383871778	Average	Dimension Time 100,218	2600 L1 30899724729	L2 54184095605
Average	Dimension Time 55,962 54,37	2200 L1 17620532070 17620904117	L2 24383871778 24270181726	Average	Dimension Time 100,218 101,456	2600 L1 30899724729 30900391590	L2 54184095605 53509711699
Average	Dimension Time 55,962 54,37 54,679	2200 L1 17620532070 17620904117 17620834279	L2 24383871778 24270181726 23380860634	Average	Dimension Time 100,218 101,456 102,012	2600 L1 30899724729 30900391590 30900919718	L2 54184095605 53509711699 54845379590
Average	Dimension Time 55,962 54,37 54,679 55,533	2200 L1 17620532070 17620904117 17620834279 17620425525	L2 24383871778 24270181726 23380860634 25088366901	Average	Dimension Time  100,218 101,456 102,012 101,757	2600 L1 30899724729 30900391590 30900919718 30901039328	L2 54184095605 53509711699 54845379590 53676078236
Average	Dimension Time 55,962 54,37 54,679 55,533 54,761	2200 L1 17620532070 17620904117 17620834279 17620425525 17620651517	L2 24383871778 24270181726 23380860634 25088366901 23448322338	Average	Dimension Time  100,218  101,456  102,012  101,757  103,05	2600 L1 30899724729 30900391590 30900919718 30901039328 30900827716	L2 54184095605 53509711699 54845379590 53676078236 54668166546
Average	Dimension Time 55,962 54,37 54,679 55,533 54,761 55,26	2200 L1 17620532070 17620904117 17620834279 17620425525 17620651517 17620399590 17620859777	L2 24383871778 24270181726 23380860634 25088366901 23448322338 24557525986	Average	Dimension Time 100,218 101,456 102,012 101,757 103,05 101,639	2600 L1 30899724729 30900391590 30900919718 30901039328 30900827716 30899680594	L2 54184095605 53509711699 54845379590 53676078236 54668166546 53977955293
Average	Dimension Time  55,962  54,37  54,679  55,533  54,761  55,26  54,403	2200 L1 17620532070 17620904117 17620834279 17620425525 17620651517 17620399590 17620859777	L2 24383871778 24270181726 23380860634 25088366901 23448322338 24557525986 24432108255	Average	Dimension Time 100,218 101,456 102,012 101,757 103,05 101,639 101,861	2600 L1 30899724729 30900391590 30900919718 30901039328 30900827716 30899680594 30901144205	L2 54184095605 53509711699 54845379590 53676078236 54668166546 53977955293 54376850897
Average	Dimension Time  55,962  54,37  54,679  55,533  54,761  55,26  54,403  54,616	2200 L1 17620532070 17620904117 17620834279 17620425525 17620651517 17620399590 17620859777 17620746915	L2 24383871778 24270181726 23380860634 25088366901 23448322338 24557525986 24432108255 24798982165	Average	Dimension Time 100,218 101,456 102,012 101,757 103,05 101,639 101,861 102,508	2600 L1 30899724729 30900391590 30900919718 30901039328 30900827716 30899680594 30901144205 30900877724	L2 54184095605 53509711699 54845379590 53676078236 54668166546 53977955293 54376850897 54273680096
Average	Dimension Time  55,962  54,37  54,679  55,533  54,761  55,26  54,403  54,616  54,432	2200 L1 17620532070 17620904117 17620834279 17620425525 17620651517 17620399590 17620859777 17620746915 17620634075	L2 24383871778 24270181726 23380860634 25088366901 2344832233 24557525986 24432108255 24798982165 24646224063	Average	Dimension Time 100,218 101,456 102,012 101,757 103,05 101,639 101,861 102,508 101,943	2600 L1 30899724729 30900391590 30900919718 30901039328 3090827716 30899680594 30901144205 30900877724 30900216387	L2 54184095605 53509711699 54845379590 53676078236 546816654 53977955293 54376850897 54273680096 54296474829
	Dimension Time  55,962 54,37 54,679 55,533 54,761 55,26 54,403 54,616 54,432 54,279 54,8295	2200 L1 17620532070 17620904117 17620834279 17620425525 17620651517 17620399590 17620859777 17620746915 17620634075 17620873043 17620686091	L2 24383871778 24270181726 23380860634 25088366901 23448322338 24557525986 24432108255 24798982165 24646224063 23925972690		Dimension Time  100,218 101,456 102,012 101,757 103,05 101,639 101,861 102,508 101,943 102,347	2600 L1 30899724729 30900391590 30900919718 30901039328 30900827716 30899680594 30901144205 30900877724 30900216387 309001187292	54184095605 53509711699 54845379590 53676078236 54668166546 5397795529 54376850897 54273680096 54296474829 54601164216
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	Dimension Time  55,962 54,37 54,679 55,533 54,761 55,26 54,403 54,616 54,432 54,279 54,8295 Dimension Time  171,533 171,119 170,061 170,752 170,076 169,928	2200 L1 17620532070 17620904117 17620834279 17620425525 17620651517 1762039595777 17620746915 17620634075 17620686091 3000 L1 50300666693 5030009897 50299837354 50299446589 50298483351	L2 24383871778 24270181726 23380860634 25088366901 23448322338 24557525986 24432108255 24798982165 24646224063 23925972690 24293241654  L2 101895549363 99973547955 100760159900 100445529209 100317063432 100129508008 101114251486		Dimension Time  100,218 101,456 102,012 101,757 103,05 101,639 101,861 102,508 101,943 102,347	2600 L1 30899724729 30900391590 30900919718 30901039328 30900827716 30899680594 30901144205 30900877724 30900216387 309001187292	54184095605 53509711699 54845379590 53676078236 54668166546 5397795529 54273680096 54296474829 54601164216
	Dimension Time  55,962 54,37 54,679 55,533 54,761 55,266 54,403 54,413 54,429 Dimension Time  171,533 171,119 170,061 170,752 170,076 169,928 170,096	2200 L1 17620532070 17620904117 17620834279 17620425525 17620651517 176203959777 17620746915 1762084075 1762086091 3000 L1 50300666693 50300090897 5029837354 50298483351 50398483351 50300617656	L2 24383871778 24270181726 23380860634 25088366901 23448322338 2455752598 24432108255 24798982165 24646224063 23925972690 24293241654  L2 101895549363 99973547955 100760159900 100445529209 100317063432 100129508008 101114251486 102304834650		Dimension Time  100,218 101,456 102,012 101,757 103,05 101,639 101,861 102,508 101,943 102,347	2600 L1 30899724729 30900391590 30900919718 30901039328 30900827716 30899680594 30901144205 30900877724 30900216387 309001187292	54184095605 53509711699 54845379590 53676078236 54668166546 5397795529 54273680096 54296474829 54601164216
	Dimension Time  55,962 54,377 54,679 55,533 54,761 55,266 54,403 54,432 54,279 54,8295  Dimension Time  171,533 171,119 170,061 170,764 170,752 170,076 169,928 170,096 171,115	2200 L1 17620532070 17620904117 17620834279 17620425525 17620651517 1762083959777 17620746915 17620634075 17620839070 1762083937343 17620686091  50300666693 5030090897 50298837354 50299483351 50298483351 50300617656 50299797338	L2 24383871778 24270181726 23380860634 25088366901 23448322338 24557525986 24432108255 24798982165 24646224063 23925972690 24293241654  L2 101895549363 99973547955 100760159900 100445529209 100317063432 100129508008 101114251486 102304834650 99826531920		Dimension Time  100,218 101,456 102,012 101,757 103,05 101,639 101,861 102,508 101,943 102,347	2600 L1 30899724729 30900391590 30900919718 30901039328 30900827716 30899680594 30901144205 30900877724 30900216387 309001187292	54184095605 53509711699 54845379590 53676078236 54668166546 53977955293 54376850897 54273680096 54296474829 54601164216
	Dimension Time  55,962 54,37 54,679 55,533 54,761 55,266 54,403 54,413 54,429 Dimension Time  171,533 171,119 170,061 170,752 170,076 169,928 170,096	2200 L1 17620532070 17620904117 17620834279 17620425525 17620651517 176203959777 17620746915 1762084075 1762086091 3000 L1 50300666693 50300090897 5029837354 50298483351 50398483351 50300617656	L2 24383871778 24270181726 23380860634 25088366901 23448322338 2455752598 24432108255 24798982165 24646224063 23925972690 24293241654  L2 101895549363 99973547955 100760159900 100445529209 100317063432 100129508008 101114251486 102304834650		Dimension Time  100,218 101,456 102,012 101,757 103,05 101,639 101,861 102,508 101,943 102,347	2600 L1 30899724729 30900391590 30900919718 30901039328 30900827716 30899680594 30901144205 30900877724 30900216387 309001187292	54184095605 53509711699 54845379590 53676078236 54668166546 53977955293 54376850897 54273680096 54296474829 54601164216

## 6.2 Normal Multiplication (Java) Measurements

Dimension	600	Dimension	1000
	Time		Time
	0,302		2,197
	0,291		2,271
	0,264		2,314
	0,262		2,263
	0,298		2,23
	0,282		2,184
	0,271		2,252
	0,269		2,088
	0,262		2,177
	0,259		2,216
Average	0,276	Average	2,2192
Dimension	1400	Dimension	1800
Dimension	1400 Time	Dimension	1800 Time
Dimension		Dimension	
Dimension	Time	Dimension	Time
Dimension	Time 6,123	Dimension	Time 27,026
Dimension	Time 6,123 6,209	Dimension	Time 27,026 26,358
Dimension	6,123 6,209 6,096	Dimension	Time 27,026 26,358 26,535
Dimension	6,123 6,209 6,096 6,105 6,096 6,099	Dimension	Time 27,026 26,358 26,535 26,25
Dimension	6,123 6,209 6,096 6,105 6,096	Dimension	Time 27,026 26,358 26,535 26,25 26,763
Dimension	6,123 6,209 6,096 6,105 6,096 6,099	Dimension	Time 27,026 26,358 26,535 26,25 26,763 25,846
Dimension	Time 6,123 6,209 6,096 6,105 6,096 6,099 6,116 6,252 6,142	Dimension	Time 27,026 26,358 26,535 26,25 26,763 25,846 24,716
Dimension	Time 6,123 6,209 6,096 6,105 6,096 6,099 6,116 6,252	Dimension	Time 27,026 26,358 26,535 26,25 26,763 25,846 24,716 25,734

Dimension	2200
	Time
	55,24
	52,624
	53,014
	52,952
	53,885
	55,195
	53,05
	52,785
	52,112
	52,042
Average	53,2899

Dimension	2600
	Time
	97,324
	96,157
	93,656
	92,492
	91,681
	91,832
	91,746
	92,414
	94,19
	94,41
Average	93,5902

Dimension	3000
	Time
	158,063
	156,787
	151,878
	152,986
	152,703
	152,996
	155,151
	152,215
	152,953
	153,184
Average	153,8916

## 6.3 Line Multiplication (C) Measurements

						,	
	Dimension	600			Dimension	1000	
	Time	L1	L2		Time	L1	L2
	0,16	27144510	57504452		0,883	125890043	258052716
	0,155	27135108	57519128		0,892	125970586	256346204
	0,15	27117526	57448876		0,834	125889214	257283982
	0,161	27154813	57583151		0,816	125798270	257409746
	0,156	27143068	57575527		0,828	125815565	256848777
	0,168	27171113	57387315		0,833	125821534	256416554
	0,166	27144229	57197940		0,839	125942298	256051182
	0,173	27185680	57411535		0,843	126242052	256084755
	0,165	27135740	57203740		0,837	126083576	255590414
	0,163	27176731	57506418		0,845	125958805	256182274
Average	0,1617	27150851,8	57433808,2	Average	0,845	125941194,3	256626660,4
	Dimension	1400			Dimension	1800	
	Time	L1	L2		Time	L1	L2
	2,509	346667347	699852160		5,353	751095682	1496936605
	2,429	346553002	699655547		5,334	760105771	1514417844
	2,409	346920621	699544120		5,242	747906035	1537682555
	2,397	346419898	699219227		5,256	749990086	1537775824
	2,387	346940426	699358638		5,306	752442239	1539115481
	2,468	351295314	700632781		5,254	747383409	1537434790
	2,41	348086974	699071216		5,261	749261261	1538246134
	2,408	347926611	698872510		5.27	749267942	1538355651
	2,417	347855383	699376642		5,269	751470483	1538675794
	2,396	346934305	699400832		5,267	750619556	1537906361
Average	2,423	347559988,1	699498367,3	Average	5,2812	750954246,4	1531654704
	Dimension	2200			Dimonsion	2600	
	Dimension	2200	12		Dimension	2600	12
	Time	L1	L2 2804154387		Time	L1	L2
	Time 9,815	L1 2084359765	2804154387		Time 16,465	L1 4411117263	4618610924
	9,815 9,883	2084359765 2110341990	2804154387 2804840976		Time 16,465 16,212	4411117263 4413766142	4618610924 4613422809
	Time 9,815 9,883 9,937	2084359765 2110341990 2110632438	2804154387 2804840976 2807508911		Time 16,465 16,212 16,158	4411117263 4413766142 4413648339	4618610924 4613422809 4613724185
	9,815 9,883 9,937 9,888	2084359765 2110341990 2110632438 2120231045	2804154387 2804840976 2807508911 2807649469		Time 16,465 16,212 16,158 16,224	4411117263 4413766142 4413648339 4413732397	4618610924 4613422809 4613724185 4614340753
	9,815 9,883 9,937 9,888 10,019	2084359765 2110341990 2110632438 2120231045 2128600454	2804154387 2804840976 2807508911 2807649469 2811859434		Time 16,465 16,212 16,158 16,224 16,182	4411117263 4413766142 4413648339 4413732397 4413692591	4618610924 4613422809 4613724185 4614340753 4614913944
	9,815 9,883 9,937 9,888 10,019 9,907	L1 2084359765 2110341990 2110632438 2120231045 2128600454 2123185877	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734		Time  16,465 16,212 16,158 16,224 16,182 16,093	L1 4411117263 4413766142 4413648339 4413732397 4413692591 4413463673	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059
	9,815 9,883 9,937 9,888 10,019 9,907 9,863	L1 2084359765 2110341990 2110632438 2120231045 2128600454 2123185877 2102690202	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808867717		Time  16,465 16,212 16,158 16,224 16,182 16,093 16,083	L1 4411117263 4413766142 4413648339 4413732397 4413692591 4413463673 4413302618	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474
	Time 9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805	L1 2084359765 2110341990 2110632438 2120231045 2128600454 2123185877 2102690202 2098514497	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808867717 2806448596		Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276	L1  4411117263  4413766142  4413648339  4413732397  4413692591  4413463673  4413302618  4408874134	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893
	7ime 9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759	L1 2084359765 2110341990 2110632438 2120231045 2128600454 2123185877 2102690202 2098514497 2101123708	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808867717 2806448596 2787013313		Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276	L1  4411117263 4413766142 4413648339 4413732397 4413692591 4413463673 4413302618 4408874134 4412418389	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261
Augrago	7ime 9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877	L1 2084359765 2110341990 2110632438 2120231045 2128600454 2123185877 2102690202 2098514497 2101123708 2104573488	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808867717 2806448596 2787013313 2727037845	Averano	Time 16,465 16,212 16,158 16,224 16,182 16,093 16,083 16,271 16,182	L1  4411117263 4413766142 4413648339 4413732397 4413632673 4413463673 4413302618 4408874134 4412418389 4413709047	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261 4614035163
Average	Time 9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,875	L1 2084359765 2110341990 2110632438 2120231045 2128600454 2123185877 2102690202 2098514497 2101123708 2104573488 2108425346	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808867717 2806448596 2787013313	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276  16,271  16,182	L1  4411117263 4413766142 4413648339 4413732397 4413692591 4413463673 4413302618 4408874134 4412418389 4413709047 4412772459	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753 Dimension	L1	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808867717 2806448596 2787013313 2727037845 2797499638	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276  16,271  16,182  16,2146  Dimension	L1  4411117263 4413766142 4413648339 4413732397 4413692591 4413463673 4413302618 4408874134 4412418389 4413709047 4412772459	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261 4614035163 4615335347
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753 Dimension	L1 2084359765 2110341990 2110632438 2120231045 2128600454 2123185877 2102690202 2098514497 2101123708 2104573488 2108425346	2804154387 2804840976 2807508911 2807649469 281185943 2809615734 2809867717 2806448596 2787013313 2727037845 2797499638	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276  16,271  16,182  16,2146  Dimension	L1  4411117263 4413766142 4413648339 4413732397 4413692591 4413463673 4413302618 4408874134 4412418389 4413709047 4412772459  4096 L1	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261 4614035163 4615335347
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753 Dimension Time  24,778	L1 2084359765 2110341990 2110632438 2120231045 2128600454 2123185877 2102690202 2098514497 2101123708 2104573488 2108425346 3000 L1 6780854930	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808867717 2806448596 2787013313 2727037845 2797499638	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,271  16,182  16,2146  Dimension  Time  63,863	L1  4411117263 4413766142 4413648339 4413732397 4413632673 4413302618 4408874134 4412418389 4413709047 4412772459  4096 L1 17706215776	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261 4614035163 4615335347
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753  Dimension Time  24,778 24,647	L1 2084359765 2110341990 2110632438 2120231045 2128600454 2123185877 2102690202 2098514497 2101123708 2104573488 2108425346 3000 L1 6780854930 6780931765	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808667717 2806448596 2787013313 2727037845 2797499638 L2 6873861163 6876984132	Average	Time  16,465  16,212  16,158  16,224  16,182  16,083  16,271  16,182  16,2146  Dimension  Time  63,863  62,105	L1  4411117263 4413766142 4413648339 4413732397 4413632673 4413302618 4408874134 4412418389 4413709047 4412772459  L1  17706215776 17721178805	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 461806893 4616664261 4614035163 4615335347 L2 17603033674 17600544872
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753  Dimension Time  24,778 24,647 24,656	L1	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808647871 2806448596 2787013313 2727037845 2797499638 L2 6873861163 6876984132 6875333585	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276  16,271  16,182  16,2146  Dimension  Time  63,863  62,105  62,359	L1  4411117263 4413766142 4413648339 441373239 4413692591 4413463673 4413302618 4408874134 4412418389 441370947 4412772459  L1  17706215776 17721178805 17711793317	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 461664261 4614035163 4615335347 L2 17603033674 17600544872 17601915282
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753  Dimension Time  24,778 24,647 24,656 24,687	L1	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808448596 2787013313 2727037845 2797499638 L2 6873861163 6876984132 6875333585 6874896836	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276  16,271  16,182  Dimension  Time  63,863  62,105  62,359  62,244	L1  4411117263 4413766142 441376339 441373239 4413692591 4413463673 4413302618 4408874134 4412418389 4413709047 4412772459  L1 17706215776 17721178805 17711793317 17718337676	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261 4614035163 4615335347 L2 L2 176003043674 17600544872 17601915282 17476377324
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753  Dimension Time  24,778 24,647 24,656	L1	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808647871 2806448596 2787013313 2727037845 2797499638 L2 6873861163 6876984132 6875333585	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276  16,271  16,182  16,2146  Dimension  Time  63,863  62,105  62,359	L1  4411117263 4413766142 4413648339 441373239 4413692591 4413463673 4413302618 4408874134 4412418389 441370947 4412772459  L1  17706215776 17721178805 17711793317	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 461664261 4614035163 4615335347 L2 17603033674 17600544872 17601915282
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753  Dimension Time  24,778 24,647 24,656 24,687	L1	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808448596 2787013313 2727037845 2797499638 L2 6873861163 6876984132 6875333585 6874896836	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276  16,271  16,182  Dimension  Time  63,863  62,105  62,359  62,244	L1  4411117263 4413766142 441376339 441373239 4413692591 4413463673 4413302618 4408874134 4412418389 4413709047 4412772459  L1 17706215776 17721178805 17711793317 17718337676	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261 4614035163 4615335347 L2 L2 176003043674 17600544872 17601915282 17476377324
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753  Dimension Time  24,778 24,647 24,656 24,687 24,619	L1	2804154387 2804840976 2807508911 2807649469 2811859434 2808615734 2808448596 2787013313 2727037845 2797499638 L2 6873861163 6876984132 6875333585 687489636 6878034158	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276  16,271  16,182  16,2146  Dimension  Time  63,863  62,105  62,359  62,244  62,686	L1  4411117263 4413766142 4413766142 441373239 441373239 4413692591 4413463673 4413302618 4408874134 4412418389 4413709047 4412772459  4096 L1 17706215776 17721178805 17711793317 17718337676 17718066828	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261 4614035163 4615335347 L2 176003033674 17600544872 17600544872 17607522 17476377324
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753 Dimension Time  24,778 24,647 24,656 24,687 24,619 24,722	L1	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808448596 2787013313 2727037845 2797499638 L2 6873861163 6876984132 6875333585 687698436 6878034158 6878034158 6878034158	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276  16,271  16,182  16,2146  Dimension  Time  63,863 62,105 62,359 62,244 62,686 62,744	L1  4411117263 4413766142 4413732397 4413692591 4413692591 4413463673 4413302618 4408874134 4412418389 4413709047 4412772459  4096 L1 17706215776 17771178337676 17718337676 17718606828 17717814101	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261 4614035163 4615335347 L2 17603033674 17600544872 17767377324 17472490775 17459303362
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753 Dimension Time  24,778 24,656 24,687 24,614	L1 2084359765 2110341990 2110632438 2120231045 2128600454 2123185877 2102690202 2098514497 2101123708 2104573488 2108425346 3000 L1 6780854930 678093769 6780998719 6780793299 6781004390 6781013367	2804154387 2804840976 2807508911 2807649469 281185943 2809615734 2809615734 2808867717 2806448596 2787013313 2727037845 2797499638 L2 6873861163 6876984132 6875333585 6874896836 6878034158 6874342814 6876035551	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,083  16,276  16,271  16,182  16,2146  Dimension  Time  63,863  62,105  62,359  62,244  62,686  62,744  62,713	L1  4411117263 4413766142 4413648339 4413732397 4413692591 4413463673 4413302618 4408874134 4412418389 4413709047 4412772459  L1 17706215776 17771178807 1771178337676 177180768288 17717814101 17719004379	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 461800893 4616664261 4614035163 4615335347 L2 17600343872 17600544872 17607377324 17472390775 17459303362 17478334613
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753 Dimension Time  24,778 24,656 24,687 24,619 24,722 24,614 24,793	L1 2084359765 2110341990 2110632438 2120231045 2128600454 2123185877 2102690202 2098514497 2101123708 2104573488 2108425346 3000 L1 6780854930 6780995719 6780793299 6781004390 6781013367 6780073414	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808867717 2806448596 2787013313 2727037845 2797499638 L2 6873861163 6876984132 6875333585 6874896836 6878034158 6874342814 6876035551 6876082639	Average	Time  16,465  16,212  16,158  16,224  16,182  16,093  16,093  16,271  16,182  16,2146  Dimension  Time  63,863 62,105  62,359 62,244 62,646 62,744 62,713 62,936	L1  4411117263 4413766142 4413648339 4413732397 4413692591 4413463673 4413302618 4408874134 4412418389 4413709047 4412772459  L1 17706215776 1771179317 177118337676 17718066828 17717814101 1771904379 17715476925	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261 4614035163 4615335347  L2 17603033674 1760915282 17476377324 17472490775 17459303362 17478334613 17479428270
Average	Time  9,815 9,883 9,937 9,888 10,019 9,907 9,863 9,805 9,759 9,877 9,8753  Dimension Time  24,778 24,647 24,656 24,687 24,619 24,722 24,614 24,793 24,716	L1	2804154387 2804840976 2807508911 2807649469 2811859434 2809615734 2808867717 2806448596 2787013313 2727037845 2797499638 L2 6873861163 6876984132 6875333585 6874896836 6878034158 6878034158 6876035551 6876082639 6876982486	Average	Time  16,465  16,212  16,158  16,224  16,182  16,083  16,276  16,271  16,182  16,2146  Dimension  Time  63,863  62,105  62,359  62,244  62,686  62,744  62,713  62,936  63,135	L1  4411117263 4413766142 4413648339 4413732397 4413692591 4413463673 4413302618 4408874134 4412418389 441370947 4412772459  L1 17706215776 177187805 1771178317 177180745925 177715476925 17711829996	4618610924 4613422809 4613724185 4614340753 4614913944 4615112059 4614468474 4618060893 4616664261 4614035163 4615335347 L2 17603033674 17600544872 17601915282 17476377324 17472490775 17459303362 17478333613 17479428270 17603288597

	Dimension	6144	
	Time	L1	L2
	209,813	59816161833	59121553292
	209,044	59813715314	59363182374
	208,103	59819117807	59432903270
	208,093	59820425152	59470575842
	207,986	59820199142	59467622180
	208,175	59820403506	59409523031
	208,073	59819528309	59427807611
	208,106	59821073811	59443745204
	208,083	59819525498	59401015327
	208,078	59821181355	59455335144
Average	208,3554	59819133173	59399326328

	Dimension	8192	
	Time	L1	L2
	503,573	141480897115	143705437426
	502,944	141477398970	143670462982
	502,49	141471363407	143626116970
	495,946	141705397762	142259619882
	495,515	141656129584	140793232493
	498,278	141501823732	140645280443
	498,519	141496068034	140564848351
	498,56	141495238364	140587253965
	498,932	141501462760	140641328314
	498,221	141500130923	140636294539
Average	499,2978	141528591065	141712987537

	Dimension	10240	
	Time	L1	L2
	972,184	276581965569	278384495537
	976,813	276560028261	274269578489
	975,318	276561634660	274286170048
	972,65	276631046703	274139662124
	966,81	276755102092	273896727855
	971,326	276560017329	274334887174
	965,508	276650824862	276264136850
	964,801	276664430247	276450736692
	965,582	276647028077	278116777542
	967,287	276614953895	282901093901
Average	969,8279	276622703170	276304426621

## ${\bf 6.4}\quad {\bf Line\ Multiplication\ (Java)\ Measurements}$

Dimension	600	Dimension	1000
	Time		Time
	0,694		1,062
	0,214		0,997
	0,195		0,854
	0,216		0,893
	0,212		1,081
	0,212		1,057
	0,215		1,108
	0,463		1,085
	0,208		1,078
	0,207		1,083
Average	0,2836	Average	1,0298
Dimension	1400	Dimension	1800
	1100	Dimonsion	1000
	Time	Dimension	Time
		Dimension	
	Time	Difficulties	Time
	Time 3,341	Difficulties	Time 7,068
	Time 3,341 3,178	Dimension	7,068 6,876
	Time 3,341 3,178 3,293	Difficulties	7,068 6,876 6,87
	3,341 3,178 3,293 3,194		7,068 6,876 6,87 6,899
	Time  3,341  3,178  3,293  3,194  3,132		7,068 6,876 6,87 6,899 6,808
	Time  3,341  3,178  3,293  3,194  3,132  3,514		7,068 6,876 6,87 6,899 6,808 6,78
	Time  3,341  3,178  3,293  3,194  3,132  3,514  3,473		7,068 6,876 6,87 6,899 6,808 6,78 6,638
	Time  3,341 3,178 3,293 3,194 3,132 3,514 3,473 3,206		7,068 6,876 6,87 6,899 6,808 6,78 6,638 6,777

Dimension		2200
	Time	
		12,906
		12,596
		12,65
		12,537
		12,484
		12,539
		12,203
		12,649
		12,493
		12,513
Average		12,557
Dimension		3000
	Time	
		32,188
		32,193
		31,947
		31,864
		32,138
		32,07
		33 726

Dimension	2600
	Time
	21,032
	20,665
	20,831
	20,677
	20,798
	20,711
	20,711
	20,784
	20,707
	20,809
Average	20,7725

## ${\bf 6.5}\quad {\bf Block\ Multiplication\ Measurements}$

	_			i			
Dimension	_	Block Size	128	Dimension		Block Size	128
	Time	L1	L2		Time	L1	L2
	56,372	9655942769	32263950240		158,839	33030672178	109150914118
	49,133	9825753539	32387020502		158,878	33029916631	109134068097
	50,747	9682736978	32268944924		171,139	33062688738	109388290419
	50,612	9693295293	32253841215		161,748	33036903750	109647199531
	52,106	9702009051	32290493321		160,035	33032376376	109567201983
	50,381	9718597916	32247653156		159,414	33032654543	109115181368
	49,072	9736628106	32219310774		159,031	33031594583	109130508034
	49,127	9756488560	32259629613		161,127	33039261531	109158595639
	54,483	9781564382	32291982687		158,918		109156210409
	54,333	9930464438	32356365771		161,45	33040009451	109336515351
Average	51,6366	9748348103	32283919220	Average	161,0579	33036985266	109278468495
Dimension	8192	Block Size	128	Dimension	10240	Block Size	128
	Time	L1	L2		Time	L1	L2
	760,288	75558203606	242350209044		734,604	152952731332	505831688169
	749,382	75577875333	242847327295		731,55	152960890025	506335833942
	728,943	75700192413	243721937547		735,887	152968137684	506280981368
	732,378	75731434817	244077008986		750,868	153581975475	508520564690
	676,086	76090056119	244598882071		805,929	152970309715	506010933360
	630,8	77975368520	251324350814		809,996	152942146755	507755796489
	440,883	77671610270	256538924382		810,013	152944706496	507689929659
	403,056	77920257805	257106276344		810,492	152944970713	507708588675
	392,71	78054183871	257650788151		799,737	152950808053	507676226967
	396,786	78073505668	257919821736		757,46	154202002026	507761851244
Average	591,1312	76835268842	249813552637	Average	774,6536	153141867827	507157239456
	001,1012	70033200042	249013332037	Average	114,0000	133141007027	307 137 239430
Dimension					6144		
		Block Size	256 L2	Dimension			256 L2
	4096	Block Size	256		6144	Block Size	256
	4096 Time 65,298	Block Size	256 L2		6144 Time	Block Size L1 30774339270	256 L2
	4096 Time	Block Size L1 9118133192	256 L2 22561081421		6144 Time 151,241	Block Size L1 30774339270	256 L2 77378402199
	4096 Time 65,298 64,88 54,207	Block Size L1 9118133192 9118812725 9123516041	256 L2 22561081421 22614813659 22767010180		6144 Time 151,241 152,309 151,214	Block Size L1 30774339270 30777015090 30801920208	256 L2 77378402199 77278944966 77232533822
	4096 Time 65,298 64,88	Block Size L1 9118133192 9118812725	256 L2 22561081421 22614813659		6144 Time 151,241 152,309	Block Size L1 30774339270 30777015090	256 L2 77378402199 77278944966
	4096 Time 65,298 64,88 54,207 54,192	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777	256 L2 22561081421 22614813659 22767010180 22757921397		6144 Time 151,241 152,309 151,214 152,525	Block Size L1 30774339270 30777015090 30801920208 30776206566	256 L2 77378402199 77278944966 77232533822 77260156182
	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491		6144 Time 151,241 152,309 151,214 152,525 152,3 149,882	Block Size L1 30774339270 30777015090 30801920208 30776206566 30781608436	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 75617059083
	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202 49,291	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772		6144 Time  151,241  152,309  151,214  152,525  152,3  149,882  151,907	Block Size L1 30774339270 30777015090 30801920208 30776206566 30781608436 30775019125	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530
	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474		6144 Time 151,241 152,309 151,214 152,525 152,3 149,882	Block Size L1 30774339270 30777015090 30801920208 30776200566 30781608436 30775019125 30780410862 30775576707	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 75617059083 75566773108
	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700		6144 Time  151,241  152,309  151,214  152,525  152,3  149,882  151,907  150,787	Block Size L1 30774339270 30777015090 30801920208 30776200566 30781608436 30775019125 30780410862 30775576707	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 75617059083 75566773108 75583027163
	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669		151,241 152,309 151,214 152,525 152,325 149,882 151,907 150,787 152,859	Block Size L1 30774339270 30777015090 30801920208 30776206566 30781608436 30775019125 30780410862 30775576707 30782942777	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 75566773108 75583027163 75788966097
Dimension	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957 45,975 52,8829	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669 22860995591 22763046735	Dimension	151,241 152,309 151,214 152,525 152,325 152,323 149,882 151,907 150,787 152,859 150,771	Block Size L1 30774339270 30777015090 30801920208 30776206566 30781608436 30775019125 30780410862 30775576707 30782942777 30779521146 30780456019	256 L2 77378402199 77278944966 77232533822 77260156182 76657050933 7556773108 75583027163 75788966097 7556827081 76393125323
Dimension	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957 45,975 52,8829	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075 Block Size	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669 22860995591 22763046735	Dimension	151,241 152,309 151,214 152,525 152,3 149,882 151,907 150,787 152,859 150,771 151,5795	Block Size L1 30774339270 30777015090 30801920208 30776206566 30781608436 30775019125 30780410862 30775576707 30782942777 30779521146 30780456019 Block Size	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 75617059083 75566773108 75583027163 75788966097 75565827081 76393125323
Dimension	4096 Time  65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957 45,975 52,8829  Time	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075 Block Size L1	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669 22860995591 22763046735	Dimension	6144 Time  151,241 152,309 151,214 152,525 152,32 149,882 151,907 150,787 152,859 150,771 151,5795	Block Size L1 30774339270 30777015090 30801920208 30776206566 30781608436 30775019125 30780410862 30775576707 30782942777 30779521146 30780456019 Block Size L1	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 75617059083 75568773108 75583027163 75788966097 75565827081 76393125323
Dimension	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957 45,975 52,8829 8192 Time 643,609	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075 Block Size L1 72371697091	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669 22763046735 256 L2 173492194573	Dimension	151,241 152,309 151,214 152,309 151,214 152,525 152,3 149,882 151,907 150,787 152,859 150,771 151,5795 10240 Time 718,4	Block Size L1 30774339270 30777015090 30801920208 30776206566 30775019125 30780410862 30775576707 30782942777 30779521146 3078045019 Block Size L1 142500496306	256 L2 77378402199 77278944966 77232533822 77260156182 776659563530 75617059083 75566773108 75583027163 7578896097 75565827081 76393125232 256 L2 353718340489
Dimension	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,977 52,8829  8192 Time 643,609 634,684	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075 Block Size L1 72371697091 72415235941	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669 22860995591 22763046735 L2 173492194573 173797832053	Dimension	151,241 152,309 151,214 152,525 152,33 149,882 151,907 150,787 152,859 150,771 151,5795 10240 Time 718,4	Block Size L1 30774339270 30777015090 30801920208 30776206566 30781608436 30775019125 30780410862 30775576707 30782942777 30779521146 30780456019 Block Size L1 142500496306 142500389049	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 7556773108 75583027163 75788966097 75565827081 256 L2 353718340489 353078078059
Dimension	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957 45,975 52,8829 8192 Time 643,609 634,684 629,097	Block Size L1  9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075 Block Size L1 72371697091 72415235941 72429274649	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22755382474 22850115700 22864688669 22860995591 22763046735 256 L2 173492194573 173797832053 173905462730	Dimension	151,241 152,309 151,214 152,305 151,214 152,525 152,3 149,882 151,907 150,787 152,859 150,771 151,5795 10240 Time 718,4 717,422 709,784	Block Size L1 30774339270 30777015090 30801920208 30776206566 307781608436 30775019125 30780410862 30775576707 30782942777 30779521146 30780456019 Block Size L1 142500496306 142500389049 142487637846	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 7556773108 75583027163 75788966097 75565827081 76393125323 256 L2 3553718340489 353078078059 355326233472
Dimension	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202 48,652 45,957 45,975 52,8829 Time 643,609 634,684 629,097 621,155	Block Size L1  9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075 Block Size L1 72371697091 72415235941 72429274649 72457374191	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669 22860995591 22763046735 256 L2 1734922194573 17397832053 173905462730 174126756633	Dimension	151,241 152,309 151,214 152,525 152,33 149,882 151,907 150,787 152,859 150,771 151,5795 10240 Time 718,4 717,422 709,784 712,294	Block Size L1 30774339270 30777015090 30801920208 30776206566 30781608436 30775019125 30780410862 30775576707 30782942777 30779521146 30780456019 Block Size L1 142500496306 142500389049 142487637846 142492248596	256 L2 77378402199 77278944966 77232533822 77260156182 7665795083 7556773108 75583027163 75788966097 75565827081 76393125323 256 L2 353718340489 353078078059 355326233472 352248260316
Dimension	4096 Time  65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957 45,975 52,8829  8192 Time 643,609 634,684 629,097 621,155 606,997	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075 Block Size L1 72371697091 72415235941 72429274649 72457374191 72484273359	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669 22860995591 22763046735 256 L2 173492194573 173905462730 174126756633 1749646717474	Dimension	151,241 152,309 151,214 152,309 151,214 152,525 152,32 149,882 151,907 150,787 152,859 150,771 151,5795 10240 Time 718,4 717,422 709,784 712,294 709,866	Block Size L1 30774339270 30777015090 30801920208 30776206566 30781608436 30775019125 30780410862 30775576707 30782942777 30779521146 30780456019 Block Size L1 142500496306 142500389049 142487637846 142492248596	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 75617059083 75568773108 75583027163 7578896097 75568827081 76393125323 256 L2 353718340489 353078078059 355326233472 3552248260316 354617976412
Dimension	4096 Time  65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957 45,975 52,8829  8192 Time 643,609 634,684 629,097 621,155 606,997 595,236	Block Size L1  9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075 Block Size L1  72371697091 72415235941 72429274649 72457374191 7248423359 72511922846	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669 22763046735 256 L2 173492194573 17397832053 173905462730 174126756633 174126756633 174167477474 175083022474	Dimension	151,241 152,309 151,214 152,309 151,214 152,525 152,32 149,882 151,907 150,787 152,859 150,771 151,5795 10240 Time 718,4 717,422 709,784 710,9866 707,738	Block Size L1 30774339270 30777015090 30801920208 30776206566 30775019125 30780410862 30775576707 30782942777 30779521146 30780456019 Block Size L1 142500496306 142500389049 142487637846 14250248956 14248758993 142492869056	256 L2 77378402199 77278944966 77232533822 77260156182 776659563530 75617059083 75566773108 755883027163 75788960097 75565827081 256 L2 353718340489 353078078059 355326233472 3552484263163 354617976412 355354605711
Dimension	4096 Time  65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957 52,8829  8192 Time 643,609 634,684 629,097 621,155 606,997 595,236 589,142	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9136639052 9130689422 9126216075 Block Size L1 72371697091 72415235941 72429274649 72457374191 72484273359 72511922846 72543838812	256 L2 22561081421 22614813659 227677010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669 22860995591 22763046735 L2 173492194573 173905462730 17416756633 17496767634 175083022474 176772846122	Dimension	151,241 152,309 151,214 152,309 151,214 152,525 152,3 149,882 151,907 150,787 152,859 150,771 151,5795 10240 Time 718,4 717,422 709,784 712,294 709,866 707,738 711,95	Block Size L1 30774339270 30777015090 30801920208 30776206566 30781608436 30775019125 30780410862 30775576707 30782942777 30779521146 30780456019 Block Size L1 142500496306 142487637846 142487637846 142487539893 142492850056 142495295385	256 L2 77378402199 77278944966 77232533822 77260156182 77565953530 75517059083 75566773108 75583027163 75788960097 75555827081 256 L2 353718340489 353078078059 355324233472 352248260316 3554617976412 355354605711 355126760925
Dimension	4096 Time  65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957 45,975 52,8829  8192 Time 643,609 634,684 629,097 621,155 606,997 595,236 588,142 583,726	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075 Block Size L1 72371697091 72415235941 72429274649 72457374191 72444273359 72511922846 72543838812 72554313874	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669 22860995591 22763046735 L2 173492194573 173797832053 173905462730 174126756633 174646717474 175083022474 176772846122 177026267240	Dimension	151,241 152,309 151,241 152,309 151,214 152,525 152,3 149,882 151,907 150,787 152,859 150,771 151,5795 10240 Time 718,4 717,422 709,784 712,294 709,866 707,738 711,95	Block Size L1 30774339270 30777015090 30801920208 30776206566 30781608436 30775019125 30780410862 30775576707 30782942777 30779521146 30780456019 Block Size L1 142500496306 142492248596 142487598993 142487598993 142498260056 142495295385 142496811870	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 75617059083 75566773108 75583027163 75788966097 75565827081 256 L2 353718340489 353078078059 355326233472 352248260316 354617976412 355126760925 352709671522
Dimension	4096 Time 65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957 45,957 52,8829 8192 Time 643,609 634,684 629,097 621,155 600,997 595,236 589,142 583,726 572,13	Block Size L1  9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075 Block Size L1 72371697091 72445235941 72429274649 724573774191 72484273359 72511922846 72543838812 72554313874 72585047859	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22755382474 22850115700 22864688669 22860995591 22763046735 256 L2 173492194573 173797832053 173905462730 174126756633 174646717474 1750783022474 176772846122 177026267240 175608079731	Dimension	151,241 152,309 151,214 152,309 151,214 152,525 152,3 149,882 151,907 150,787 152,859 150,771 151,5795 10240 Time 718,4 717,422 709,784 712,294 709,866 707,738 711,95 707,192 706,476	Block Size L1 30774339270 30777015090 30801920208 30776206566 3077610962 30776206566 30778019125 30780410862 30775576707 30782942777 30779521146 30780456019 Block Size L1 142500496306 14249789933 14249286056 14248758993 14249286056 14249593371	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 755673108 75583027163 75788966097 75565827081 256 L2 3553718340489 353078078059 355326233472 352248260316 354617976412 35537607511
Dimension	4096 Time  65,298 64,88 54,207 54,192 51,175 49,202 49,291 48,652 45,957 45,975 52,8829  8192 Time 643,609 634,684 629,097 621,155 606,997 595,236 588,142 583,726	Block Size L1 9118133192 9118812725 9123516041 9124197280 9126598777 9127824064 9128208926 9128541271 9135639052 9130689422 9126216075 Block Size L1 72371697091 72415235941 72429274649 72457374191 72444273359 72511922846 72543838812 72554313874	256 L2 22561081421 22614813659 22767010180 22757921397 22777140772 22841317491 22735382474 22850115700 22864688669 22860995591 22763046735 L2 173492194573 173797832053 173905462730 174126756633 174646717474 175083022474 176772846122 177026267240	Dimension	151,241 152,309 151,241 152,309 151,214 152,525 152,3 149,882 151,907 150,787 152,859 150,771 151,5795 10240 Time 718,4 717,422 709,784 712,294 709,866 707,738 711,95	Block Size L1 30774339270 30777015090 30801920208 30776206566 3077610962 30776206566 30778019125 30780410862 30775576707 30782942777 30779521146 30780456019 Block Size L1 142500496306 14249789933 14249286056 14248758993 14249286056 14249593371	256 L2 77378402199 77278944966 77232533822 77260156182 76659563530 7556773108 75583027163 7558896097 75565827081 256 L2 353718340489 353078078059 355326233472 352248260316 354617976412 3553183605711 3555126760925 352709671522

Dimension	4096	Block Size	512	Dimension	6144	Block Size	512
	Time	L1	L2		Time	L1	L2
	62,625	8808574157	18912134656		189,48	29704107873	64498832883
	58,797	8775406129	19097842450		185,405	29695952810	64342059203
	60,208	8795662403	19201464832		194,228	29733747630	64733016716
	55,274	8764576416	18871839514		192,412	29720929719	64428130589
	59,046	8796238864	18764264257		184,295	29690491881	63767292301
	62,978	8811284676	19017748790		184,115	29644714355	64159861650
	65,321	8817121504	19128052413		182,369	29687349126	63767404166
	86,027	8903406599	19576457871		182,28	29687441087	63774086132
	70,995	8832091241	19006943593		186,425	29692016062	65042682126
	61,031	8777163590	18970710003		179,07	29641559193	63677066632
Average	64,2302	8808152558	19054745838	Average	186.0079	29689830974	64219043240
,ge	0.1,2002	0000102000	10004140000	Average	100,0019	28008030814	042 13043240
Dimension	· ·	Block Size	512	Dimension	,	Block Size	512
	· ·				,		
	8192	Block Size	512		10240	Block Size	512
	8192 Time	Block Size	512 L2		10240 Time	Block Size L1 137723493910	512 L2
	8192 Time 515,549	Block Size L1 70640958077 70578444890	512 L2 149353505458		10240 Time 1024,671	Block Size L1 137723493910	512 L2 300944492736
	8192 Time 515,549 505,148	Block Size L1 70640958077 70578444890	512 L2 149353505458 150352046603		10240 Time 1024,671 1006,418	Block Size L1 137723493910 137603681529 137260708045	512 L2 300944492736 300212413523
	8192 Time 515,549 505,148 475,479	Block Size L1 70640958077 70578444890 70189505177	512 L2 149353505458 150352046603 150923157633		10240 Time 1024,671 1006,418 817,62	Block Size L1 137723493910 137603681529 137260708045 137271400864	512 L2 300944492736 300212413523 294490633133
	8192 Time 515,549 505,148 475,479 483,416	Block Size L1 70640958077 70578444890 70189505177 70445166816	512 L2 149353505458 150352046603 150923157633 151166317549		10240 Time 1024,671 1006,418 817,62 821,558	Block Size L1 137723493910 137603681529 137260708045 137271400864 137212307289	512 L2 300944492736 300212413523 294490633133 294824164298
	8192 Time 515,549 505,148 475,479 483,416 468,975	Block Size L1 70640958077 70578444890 70189505177 70445166816 70393237302 70242107232	512 L2 149353505458 150352046603 150923157633 151166317549 150826897718		10240 Time 1024,671 1006,418 817,62 821,558 818,18	Block Size L1 137723493910 137603681529 137260708045 137271400864 137212307289	512 L2 300944492736 300212413523 294490633133 294824164298 294756315182
	8192 Time 515,549 505,148 475,479 483,416 468,975 457,638	Block Size L1 70640958077 70578444890 70189505177 70445166816 70393237302 70242107232 70666367212	512 L2 149353505458 150352046603 150923157633 151166317549 150826897718 150542943540 150055536166		10240 Time 1024,671 1006,418 817,62 821,558 818,18 820,593	Block Size L1 137723493910 137603681529 137260708045 137271400864 137212307289 137267667369	512 L2 300944492736 300212413523 294490633133 294824164298 294756315182 294786151136
	8192 Time 515,549 505,148 475,479 483,416 468,975 457,638 512,537	Block Size L1 70640958077 70578444890 70189505177 70445166816 70393237302 70242107232 70666367212	512 L2 149353505458 150352046603 150923157633 151166317549 150826897718 150542943540 150055536166 150084626416		Time 1024,671 1006,418 817,62 821,558 818,18 820,593 818,927	Block Size L1 137723493910 137603681529 137260708045 137271400864 137212307289 137267667369 137274373621	512 L2 300944492736 300212413523 294490633133 294824164298 294756315182 294786151136 294794425260
	8192 Time 515,549 505,148 475,479 483,416 468,975 457,638 512,537 512,434	Block Size L1 70640958077 70578444890 70189505177 70445166816 70393237302 70242107232 70666367212 70664133970	512 L2 149353505458 150352046603 150923157633 151166317549 150826897718 150542943540 150055536166 150084626416		10240 Time 1024,671 1006,418 817,62 821,558 818,18 820,593 818,927 818,691	Block Size L1 137723493910 137603681529 137260708045 137271400864 137212307289 137267667369 137274373621 137266464437 137225701532	512 L2 300944492736 300212413523 294490633133 294824164298 294756315182 294786151136 294794425260 294896819832

# 6.6 Line Multiplication Parallel Implementation A Measurements

	Dimension	600			Dimension	1000	
		L1	L2		Time	L1	L2
	0,0526132	2923730	6012588		0,191789	9252857	19951386
	0,0452943	3335795	6803308		0,189911	9670097	20247575
	0,0506207	3377618	6885462		0,200636	10152970	21172752
	0,0535642	3277546	6697324		0,190748	8888318	19288855
	0,0479309	3380021	6895075		0,20274	9104724	19531924
	0,0460817	3403934	6936843		0,199517	11488211	24066549
	0,0532249	3150519	6407274		0,197844	8864089	19274490
	0,051657	3228385	6495466		0,197435	9074653	19546821
	0,0528572	3159062	6370808		0,201619	8970892	18848582
	0,0493365	3217586	6053328		0,1953	9077196	19466374
Average	0,05031806	3245419,6	6555747,6	Average	0,1967539	9454400,7	20139530,8
	Dimension	1400			Dimension	1800	
	T:				_		
	Time	L1	L2		Time	L1	L2
	0,509037	L1 40910548	L2 48890709		1,11638	L1 141455866	115750777
	0,509037	40910548	48890709		1,11638	141455866	115750777
	0,509037 0,516273	40910548 40281593	48890709 47922578		1,11638 1,21263	141455866 152494263	115750777 136490264
	0,509037 0,516273 0,508784	40910548 40281593 57880773	48890709 47922578 64371399		1,11638 1,21263 1,39419	141455866 152494263 148040517	115750777 136490264 123015187
	0,509037 0,516273 0,508784 0,514987	40910548 40281593 57880773 40963142	48890709 47922578 64371399 49274870		1,11638 1,21263 1,39419 1,22012	141455866 152494263 148040517 168899836	115750777 136490264 123015187 181263953
	0,509037 0,516273 0,508784 0,514987 0,518407	40910548 40281593 57880773 40963142 42734127	48890709 47922578 64371399 49274870 50932201		1,11638 1,21263 1,39419 1,22012 1,15782	141455866 152494263 148040517 168899836 141882874	115750777 136490264 123015187 181263953 112606446
	0,509037 0,516273 0,508784 0,514987 0,518407 0,512737	40910548 40281593 57880773 40963142 42734127 56744174	48890709 47922578 64371399 49274870 50932201 61115226		1,11638 1,21263 1,39419 1,22012 1,15782 1,08087	141455866 152494263 148040517 168899836 141882874 136976095	115750777 136490264 123015187 181263953 112606446 101342148
	0,509037 0,516273 0,508784 0,514987 0,518407 0,512737 0,51413	40910548 40281593 57880773 40963142 42734127 56744174 47172668	48890709 47922578 64371399 49274870 50932201 61115226 52245930		1,11638 1,21263 1,39419 1,22012 1,15782 1,08087 1,27173	141455866 152494263 148040517 168899836 141882874 136976095 144981114	115750777 136490264 123015187 181263953 112606446 101342148 117823104
	0,509037 0,516273 0,508784 0,514987 0,518407 0,512737 0,51413 0,532248	40910548 40281593 57880773 40963142 42734127 56744174 47172668 51123548	48890709 47922578 64371399 49274870 50932201 61115226 52245930 58068599		1,11638 1,21263 1,39419 1,22012 1,15782 1,08087 1,27173 1,09943	141455866 152494263 148040517 168899836 141882874 136976095 144981114 173857102	115750777 136490264 123015187 181263953 112606446 101342148 117823104

1	-						
	Dimension				Dimension	2600	
	Time	L1	L2		Time	L1	L2
	2,00946	257242810	196995609		3,31137	390072707	260569622
	2,06046	304384645	301554619		3,343	503169163	495314044
	1,99746	266188859	214908550		3,33303	474508222	435901149
	2,00592	284355192	254654626		3,28166	507965965	513845083
	1,99386	267666244	218422377		3,30841	487203972	468769882
	1,99607	276387352	237093086		3,39579	436844389	357100206
	1,9783	258838149	201386629		3,57365	418373122	315051586
	2,00323	299810710	291328456		3,28986	433513009	346550620
	2,07611	270626046	226503136		3,47784	466544960	420252467
	2,00648	258918798	201776712		3,47421	442070968	365711317
Average	2,012735	274441880,5	234462380	Average	3,378882	456026647,7	397906597,6
	Dimension	3000		1	Dimension	4096	
	Time	L1	L2		Time	L1	L2
	5,16888	726821805	677850619		15,2224	1817893844	1596928117
	5,76075	721602198	654735782		13,5625	2107258606	2312386724
	5,69825	769247286	747888284		14,0548	1797884279	1563363962
	5,39462	789112373	795578632		16,5967	2004489261	1980744685
	5,16283	667088507	535737111		16,3514	2077061307	2124066226
	5,60336	716945948	634586631		19,2409	2160072803	2260414867
	5,1312	661564366	525088522		15,7707	2001965766	1982877395
	5,19222	656330600	508098919		17,7838	2079085349	2145644128
	6,53351	822740089	841466617		18,6411	2154560238	2272819908
	6,63748	807514308	810483282		16,0099	1956754677	1892142347
Average	5,62831	733896748	673151439,9	Average	16,32342	2015702613	2013138836
	Dimension	6144		<b>1</b>	Dimension	8192	
	Time	L1	L2		Time	L1	L2
	45,8711	5841921895	5697038196		117,485	16261614283	23088630299
	50,5034	6570309964	7558343511		118,236	16498112862	23648060727
	51,2766	6924996735	8513896599		121,077	16146943132	22507234387
	51,3495	7117004652	9090042486		122,055	16981750038	25139512094
	49,1039	5856331381	5731330629		119,832	16299478140	23798432977
	50,4642	6531128341	7503461059		120,835	15989549782	22625366773
	50,4199	6948892265	8797289153		118,609	15615872137	21660725401
	49,8202	6993496453	8915502749		120,798	16340661211	23128338391
	51,0042	7107428351	9195667239		123,214	16168870726	22726192133
	50,4949	6453123496	7296025638		124,974	16403452283	23679664963
Average	50,03079	6634463353	7829859726	Average	120,7115	16270630459	23200215815
	Dimension	10240					
	Dimension Time	L1	L2				
	240,678	28023928616	33975345845				
	236,272	33087895185	52205496671				
	241,954	32499349154	49669505252				
	241,917	32683403784	51480013367				
	244,075	33288572897	53396800146				
	248,252	32772206495	50411851767				
	243,286	28281249202	34599943832				
	245,427	33183663221	52016757658				
	249,999	33410549073	53797575939				
Average	245,238 243,7098	33517539301 32074835693	54277176101 48583046658				
	743 / 1198	1 3/0/4833693	<ul><li>4おろみろり4りりろろ</li></ul>				

## 6.7 Line Multiplication Parallel Implementation B Measurements

	_						
	Dimension				Dimension	1000	
	Time	L1	L2		Time	L1	L2
	0,224466	4996919	7843732		0,659334	32703823	34782939
	0,215194	5096542	7685282		0,663953	33906346	36684830
	0,224137	4999290	7450600		0,664477	32579541	34914154
	0,215968	4902100	8100521		0,764477	31364220	37203608
	0,217905	5000203	8036475		0,672664	32748318	36111255
	0,222805	4969207	8122814		0,696356	33703802	36711294
	0,21785	4961790	8172133		0,712855	31044315	34076438
	0,216867	5005687	8161815		0,720421	32305983	33617514
	0,222298	4936727	6193848		0,804005	33789277	36419097
	0,217362	4949694	7931944		0,823552	32510919	35941435
Average	0,2194852	4981815,9	7769916,4	Average	0,7182094	32665654,4	35646256,4
	Dimension	1400			Dimension	1800	
	Time	L1	L2		Time	L1	L2
	1,42605	95444553	92902587		2,74028	195649590	195671078
	1,41573	89068474	79145589		3,10295	202370396	205266055
	1,43502	95491103	91678408		2,78094	194200730	185755780
	1,41739	95069738	92054564		2,82083	192476050	183681900
	1,4281	97480214	93244419		3,02278	194422023	192027035
	1,4333	82196578	65121147		3,19046	201070249	206859060
	1,43919	78897149	51620557		3,26118	193280820	204769237
	1,41852	83325529	58911784		3,43509	200435324	206959464
	1,43014	87402672	77531700		3,06041	199205328	200611594
	1,43012	97590096	98408661		2,69137	202121039	200169488
Average	1,427356	90196610,6	80061941,6	Average	3,010629	197523154,9	198177069,1
	Dimension	2200			Dimension	2600	
	Dimension Time	2200 L1	L2		Dimension Time	2600 L1	L2
	Time	L1			Time	L1	
			L2 361021297 317329460				L2 485023783 473689173
	Time 4,27976 4,20821	L1 360139931	361021297		Time 6,2977	L1 535310400	485023783
	Time 4,27976	L1 360139931 338534186	361021297 317329460		Time 6,2977 6,30048	535310400 528351618	485023783 473689173
	Time 4,27976 4,20821 4,14641	360139931 338534186 331854453	361021297 317329460 280396641		6,2977 6,30048 6,33596 6,34126	535310400 528351618 549017257	485023783 473689173 520876211
	Time 4,27976 4,20821 4,14641 4,22852 4,21535	360139931 338534186 331854453 293146340	361021297 317329460 280396641 220593757		6,2977 6,30048 6,33596	535310400 528351618 549017257 528201017	485023783 473689173 520876211 472106424
	Time 4,27976 4,20821 4,14641 4,22852	360139931 338534186 331854453 293146340 343901589	361021297 317329460 280396641 220593757 332358351		6,2977 6,30048 6,33596 6,34126 6,36766	535310400 528351618 549017257 528201017 564136876	485023783 473689173 520876211 472106424 555218152
	Time 4,27976 4,20821 4,14641 4,22852 4,21535 4,1518	L1 360139931 338534186 331854453 293146340 343901589 326821199	361021297 317329460 280396641 220593757 332358351 290855506		6,2977 6,30048 6,33596 6,34126 6,36766 6,32775	535310400 528351618 549017257 528201017 564136876 496649526	485023783 473689173 520876211 472106424 555218152 411495528
	Time  4,27976  4,20821  4,14641  4,22852  4,21535  4,1518  4,21022	L1  360139931 338534186 331854453 293146340 343901589 326821199 320870485	361021297 317329460 280396641 220593757 332358351 290855506 271079851		6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,47837	535310400 528351618 549017257 528201017 564136876 496649526 497540899	485023783 473689173 520876211 472106424 555218152 411495528 411379940
	Time  4,27976  4,20821  4,14641  4,22852  4,21535  4,1518  4,21022  4,25751	L1  360139931 338534186 331854453 293146340 343901589 326821199 320870485 315010156	361021297 317329460 280396641 220593757 332358351 290855506 271079851 271309995		6,2977 6,30048 6,33596 6,34156 6,36766 6,32775 6,47837 6,41156	L1 535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243
Average	Time  4,27976  4,20821  4,14641  4,22852  4,21535  4,1518  4,21022  4,25751  4,18588	L1  360139931 338534186 331854453 293146340 343901589 326821199 320870485 315010156 353401839	361021297 317329460 280396641 220593757 332358351 290855506 271079851 271309995 355718958	Average	6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,47837 6,41156	L1 535310400 528351618 549017257 528201017 664136876 496649526 497540899 599711534 591612122	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924
Average	Time  4,27976  4,20821  4,14641  4,22852  4,21535  4,1518  4,21022  4,25751  4,18588  4,26043  4,214409	L1 360139931 338534186 331854453 29314630 343901589 326821199 320870485 315010156 353401839 360557626 334423780,4	361021297 317329460 280396641 220593757 332358351 290855506 271079851 271309995 355718958 373560047	Average	Time 6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,47837 6,41156 6,46524 6,36525 6,369123	L1 535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530
Average	Time  4,27976  4,20821  4,14641  4,22652  4,21535  4,1518  4,21022  4,25751  4,18588  4,26043  4,214409  Dimension	L1  360139931 338534186 331854453 293146340 34390158 326821199 320870485 315010156 353401839 360557626 334423780,4	361021297 317329460 280396641 220593757 332358357 290855506 271079851 271309995 355718958 373560047 307422386,3	Average	6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,47837 6,41156 6,46524 6,36525 6,369123  Dimension	L1 535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990,8
Average	Time  4,27976  4,20821  4,14641  4,22652  4,21535  4,1518  4,21022  4,25751  4,18588  4,26043  4,214409  Dimension Time	L1  360139931 338534186 331854453 293146340 34390158 326821199 320870485 315010156 353401839 360557626 334423780,4  3000 L1	361021297 317329460 280396641 220593757 332358351 290855506 271079851 271309995 355718958 373560047 307422386,3	Average	Time 6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,47837 6,41156 6,46524 6,36525 6,369123  Dimension Time	L1 535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139 4096 L1	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990,8
Average	Time  4,27976  4,20821  4,14641  4,22852  4,21535  4,1518  4,21022  4,25751  4,18588  4,26043  4,214409  Dimension  Time  9,31976	L1  360139931 338534186 331854453 293146340 343901589 326821199 320870485 315010156 353401839 360557626 334423780,4  3000 L1 864848379	361021297 317329460 280396641 220593757 332358351 29085550 271079851 271309995 355718958 373560047 307422386,3	Average	Time 6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,47837 6,41156 6,46524 6,36525 6,369123  Dimension Time 20,4262	L1 535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139 4096 L1 2143167325	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990,8
Average	Time  4,27976  4,20821  4,14641  4,22652  4,21535  4,1518  4,21022  4,25751  4,18588  4,26043  4,214409  Dimension  Time  9,31976  9,04624	L1  360139931 338534186 331854453 293146340 343901589 326821199 320870485 315010156 353401839 360557626 334423780,4  3000 L1  864848379 877755900	361021297 317329460 280396641 220593757 332358351 290855506 271079851 271309995 355718958 373560047 307422386,3 L2 886199294 922729739	Average	6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,47837 6,41156 6,46524 6,369123  Dimension Time 20,4262 20,4601	L1 535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139 4096 L1 2143167325 1932501394	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990,8
Average	Time  4,27976 4,20821 4,14641 4,22852 4,21535 4,1518 4,21022 4,25751 4,18588 4,26043 4,214409  Dimension Time  9,31976 9,04624 9,06548	L1 360139931 338534186 331854453 293146340 343901589 320870485 315010156 353401839 36055762 334423780,4  L1 864848379 877755900 878071440	361021297 317329460 280396641 220593757 332358351 290855506 271079851 27130995 355718958 373560047 307422386,3 L2 886199294 922729739 937588016	Average	6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,47837 6,41156 6,46524 6,36525 6,369123  Dimension Time 20,4262 20,4601 20,5706	L1 535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139 4096 L1 2143167325 1932501394 2162867120	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990,8 L2 2301005295 1801509177 2334301052
Average	Time  4,27976 4,20821 4,14641 4,22852 4,21535 4,1518 4,21022 4,25751 4,18588 4,26043 4,214409  Dimension  Time 9,31976 9,04624 9,06548 9,05053	L1  360139931 338534186 331854453 29314630 343901589 320870485 315010156 353401839 360557626 334423780,4  3000 L1  864848379 877755900 878071440 843565799	361021297 317329460 280396641 220593757 332358351 290855506 271079851 271309995 355718958 373560047 307422386,3 L2 886199294 922729739 937588016 852257359	Average	6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,47837 6,41156 6,46524 6,36525 6,369123  Dimension Time 20,4262 20,4601 20,5706 21,3031	L1 535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139 4096 L1 2143167325 1932501394 2162867120 2225035642	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990,8 L2 2301005295 1801509177 2334301052 2482088204
Average	Time  4,27976  4,20821  4,14641  4,22852  4,21535  4,1518  4,21022  4,25751  4,18588  4,26043  4,214409  Dimension  Time  9,31976  9,04624  9,06548  9,05053  9,00798	L1  360139931 338534186 331854453 293146303 343901589 320870485 315010156 353401839 360557626 334423780,4  864848379 8777755900 878071440 843565799 880726194	361021297 317329460 280396641 220593757 332358351 290855506 271079851 271309995 355718958 373560047 307422386,3 L2 886199294 922729739 937588016 852257359 937055620	Average	6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,41156 6,46524 6,36525 6,369123  Dimension Time 20,4262 20,4601 20,5706 21,3031 21,1487	L1  535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139  4096 L1  2143167325 1932501394 2162867120 2225035642 2271169784	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990,8  L2 2301005295 1801509177 2334301052 2482088204 2555511408
Average	Time  4,27976  4,20821  4,14641  4,22852  4,21535  4,1518  4,21022  4,25751  4,18588  4,26043  4,214409  Dimension  Time  9,31976  9,04624  9,06548  9,05053  9,00798  9,21131	L1  360139931 338534186 331854453 29314630 343901589 326821199 320870485 315010156 353401839 360557626 334423780,4  3000 L1  864848379 877755900 878071440 843565799 880726194 897523450	361021297 317329460 280396641 220593757 332358351 290855506 271079851 271309995 355718958 373560047 307422386,3 L2 886199294 922729739 937588016 852257359 937055620 977441316	Average	Time 6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,41156 6,46524 6,36525 6,369123 Dimension Time 20,4262 20,4601 20,5706 21,3031 21,1487 21,1435	L1  535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139 4096 L1 2143167325 1932501394 2162867120 2225035642 2271169784 2191099796	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990,8 L2 2301005295 1801509177 2334301052 2482088204 2555511408 2379236847
Average	Time  4,27976  4,20821  4,14641  4,22652  4,21535  4,1518  4,21022  4,25751  4,18588  4,26043  4,214409  Dimension  Time  9,31976  9,04624  9,06548  9,05053  9,00798  9,21131  9,08417	L1  360139931 338534186 331854453 293146340 343901589 320870485 315010156 353401839 360557626 334423780,4  3000 L1  864848379 87775590 878071440 843565799 880726194 897523450 869280210	361021297 317329460 280396641 220593757 332358351 290855506 271079851 271309995 355718958 373560047 307422386,3 L2 886199294 922729739 937588016 852257359 937055620 977441316	Average	Time 6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,41156 6,46524 6,36525 6,369123  Dimension Time 20,4262 20,4601 20,5706 21,3031 21,1487 21,1435 24,4082	L1 535310400 528351618 549017257 528201017 564136876 496526 497540899 599711534 591612122 587470141 547800139 4096 L1 2143167325 1932501394 2162867120 2225035642 2271169784 2191099796 2264036077	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990,8  L2 2301005295 1801509177 2334301052 2482088204 2555511408 2379236847 2472566394
Average	Time  4,27976  4,20821  4,14641  4,22652  4,21535  4,1518  4,21022  4,25751  4,18588  4,26043  4,214409  Dimension  Time  9,31976  9,04624  9,05548  9,05053  9,00798  9,21131  9,08417  9,29807	L1  360139931 338534186 331854453 293146340 343901589 326821199 320870485 315010156 353401839 360557626 334423780,4  864848379 877755900 878071440 843565799 880726194 897523450 869280210 798776553	361021297 317329460 280396641 220593757 332358351 290855506 271079851 271309995 355718958 373560047 307422386,3 L2 886199294 922729739 937588016 852257359 937055620 977441316 930126273 766382156	Average	Time 6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,41156 6,46524 6,36525 6,369123  Dimension Time 20,4262 20,4601 20,5706 21,3031 21,1487 21,1435 24,4082 22,1064	L1 535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139 4096 L1 2143167325 1932501394 2162867120 2225035642 2271169784 2191099796 2264036077 2261485233	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990,8 L2 2301005295 1801509177 2334301052 2482088204 2555511408 2379236847 2472566394 2504118135
Average	Time  4,27976 4,20821 4,14641 4,22852 4,21535 4,1518 4,21022 4,25751 4,18588 4,26043 4,214409  Dimension Time  9,31976 9,04624 9,06548 9,05053 9,00798 9,21131 9,08417 9,29807 9,29613	L1 360139931 338534186 331854433 293146340 343901589 320870485 315010156 353401839 36055762 334423780,4  L1 864848379 877755900 878071440 843565799 880726194 897523450 869280210 798776553 693778695	361021297 317329460 280396641 220593757 332358351 29085550 271079851 271309995 355718958 373560047 307422386,3 L2 886199294 922729739 937588016 852257359 937055620 977441316 930126273 766382156 512993659	Average	Time 6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,47837 6,41156 6,46524 6,36525 6,369123  Dimension Time 20,4262 20,4601 20,5706 21,3031 21,1487 21,1435 24,4082 22,1064 21,0883	L1 535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139 4096 L1 2143167325 1932501394 2162867120 2225035642 2271169796 2264036077 2261485233 2242296763	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990,8  L2 2301005295 1801509177 2334301052 2482088204 2555513408 2575236847 2472566394 2504118135 2479535827
Average	Time  4,27976  4,20821  4,14641  4,22652  4,21535  4,1518  4,21022  4,25751  4,18588  4,26043  4,214409  Dimension  Time  9,31976  9,04624  9,05548  9,05053  9,00798  9,21131  9,08417  9,29807	L1  360139931 338534186 331854453 293146340 343901589 326821199 320870485 315010156 353401839 360557626 334423780,4  864848379 877755900 878071440 843565799 880726194 897523450 869280210 798776553	361021297 317329460 280396641 220593757 332358351 290855506 271079851 271309995 355718958 373560047 307422386,3 L2 886199294 922729739 937588016 852257359 937055620 977441316 930126273 766382156	Average	Time 6,2977 6,30048 6,33596 6,34126 6,36766 6,32775 6,41156 6,46524 6,36525 6,369123  Dimension Time 20,4262 20,4601 20,5706 21,3031 21,1487 21,1435 24,4082 22,1064	L1 535310400 528351618 549017257 528201017 564136876 496649526 497540899 599711534 591612122 587470141 547800139 4096 L1 2143167325 1932501394 2162867120 2225035642 2271169784 2191099796 2264036077 2261485233	485023783 473689173 520876211 472106424 555218152 411495528 411379940 637034243 620214924 612641530 519967990.8 L2 2301005295 1801509177 2334301052 2482088204 2555511408 2379236847 2472566394 2504118135

	Dimension	6144	
	Time	L1	L2
	60,9454	7101689809	9066179378
	63,7106	7527073867	10111699991
	63,2497	6305367172	6845921647
	64,3836	6862812451	8228866667
	63,0899	5938538967	5947553776
	64,0929	7387387323	9725433592
	63,5624	6734069099	7716832024
	64,7389	6749234163	7821902509
	65,6539	6442056447	7121543879
	65,0043	6290276475	6874203470
Average	63,84316	6733850577	7946013693

	Dimension	8192	
	Time	L1	L2
	146,793	17327347596	25186876023
	151,837	16961510068	24282099788
	148,033	15935201890	21978539165
	150,265	15978125959	21820971721
	149,204	15998488746	22191097224
	149,332	17520192832	27106258054
	149,765	17837206258	28035976057
	148,339	17433480361	27050142845
	151,081	17036311776	25071676446
	148,483	17317472762	26261008057
Average	149,3132	16934533825	24898464538

	Dimension	10240	
	Time	L1	L2
	281,394	33620164785	54685841275
	285,851	34427457924	58725228662
	274,689	30728187778	45485532829
	291,256	33922165594	56707907502
	297,945	34576693149	58764284397
	283,262	34358197586	58964554027
	296,734	33971716463	55285345676
	288,25	33545503840	54782741465
	295,379	34024030319	55470136317
	288,544	32007827446	49957162613
Average	288,3304	33518194488	54882873476