**Work Assignment Report**

**University of Minho**

**Master in Informatics Engineering**

Distributed Parallel Computing

Advanced Architectures

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# Abstract

# Introduction

# Testing Environment

The computer used in the current work assignment was an MSI GE60 2QE 1026XPT Apache Pro laptop. This computer main features are displayed on Hardware Characterization chapter, such as the description of its processor and cache, and some information about the RAM. The software used is described on Software Characterization.

## Hardware Characterization

* Manufacturer: MSI
* Model: GE60 2QE 1026XPT (Apache Pro)
* Motherboard: MSI MS-16GF
* CPU chip
  + Manufacturer: Intel
  + Model: Core i7-4720HQ
  + Reference: [1]
  + Number of Cores: 4
  + Number of Threads: 8
  + Base Frequency: 2.6 GHz
  + Maximum Turbo Frequency: 3.6 GHz
  + Instruction Set: 64-bit
  + Architecture: Haswell
  + 16 DP FLOPs/cycle
  + Theoretical Peak Performance (DP): 166 GFLOPS
  + Benchmark Peak Performance (DP): 128 GFLOPS
* Cache
  + L1 Data Cache Size: 4 x 32 KB
  + L1 Instructions Cache Size: 4 x 32 KB
  + L2 Unified Cache Size: 4 x 256 KB
  + L3 Unified Cache Size: 6144 KB
* RAM
  + Manufacturer: Kingston
  + Size: 8 GB
  + DDR3L
  + 1600 MHz
  + Latency: 11 clock cycles
  + Maximum Memory Bandwidth: 13 GB/s

Both theoretical and benchmark achieved values are for double precision. The formula used to obtain the theoretical value was: [2]. Which in this case is the same as: , as this processor can execute 16 double precision floating point operations per clock cycle. The result of this equation is the theoretical value of 166.4 GFLOPS. The theoretical value for single precision floating point operations per second is 332.8 GFLOPS. Converting the benchmark value to single precision results in 256 GFLOPS.

The majority of the values presented were gathered from the Intel page [1] about the CPU and from HWiNFO64 (version 5.10) [3] and Speccy [4] which are system information tools.

## Software Characterization

The operative system used throughout the assignment was Ubuntu 14.04. The C code compiler used was <???????>. PAPI 5.4.1 [5] was used for all performance measurements presented on this report. The benchmark used to calculate the peak performance was “Linpack” [6] (the output file can be found under Linpack Output (DP)). The benchmark used to calculate the Maximum Memory Bandwidth was “Bandwidth” version 1.1 [7].

# Roofline Model

# Conclusion

# References

|  |  |
| --- | --- |
| [1] | "Intel® Core™ i7-4720HQ Processor," Intel, [Online]. Available: http://ark.intel.com/products/78934/Intel-Core-i7-4720HQ-Processor-6M-Cache-up-to-3\_60-GHz. |
| [2] | S. W. Williams, A. Waterman and D. A. Patterson, Roofline: An Insightful Visual Performance Model for Floating-Point Programs and Multicore Architectures, Berkeley: University of California, 2008. |
| [3] | M. Malík, "HWiNFO," [Online]. Available: http://www.hwinfo.com/. |
| [4] | "Speccy," Piriform, [Online]. Available: https://www.piriform.com/speccy. |
| [5] | Innovative Computing Laboratory, "PAPI," University of Tennessee, 29 November 2015. [Online]. Available: http://icl.cs.utk.edu/papi/. |
| [6] | J. Dongarra, "LINPACK," [Online]. Available: http://www.netlib.org/linpack/. |
| [7] | Z. T. Smith, "Bandwidth," 2015. [Online]. Available: http://zsmith.co/bandwidth.html. |

# Annexes

## Linpack Output (DP)

Current date/time: Wed Nov 25 19:30:19 2015

CPU frequency: 2.593 GHz

Number of CPUs: 1

Number of cores: 4

Number of threads: 8

Parameters are set to:

Number of tests: 1

Number of equations to solve (problem size) : 30000

Leading dimension of array : 30000

Number of trials to run : 8

Data alignment value (in Kbytes) : 4

Maximum memory requested that can be used=7200604096, at the size=30000

================== Timing linear equation system solver =================

Size LDA Align. Time(s) GFlops Residual Residual(norm) Check

30000 30000 4 146.730 122.6867 8.668107e-10 3.416977e-02 pass

30000 30000 4 144.283 124.7675 8.668107e-10 3.416977e-02 pass

30000 30000 4 140.143 128.4533 8.668107e-10 3.416977e-02 pass

30000 30000 4 139.828 128.7423 8.668107e-10 3.416977e-02 pass

30000 30000 4 140.608 128.0286 8.668107e-10 3.416977e-02 pass

30000 30000 4 144.802 124.3198 8.668107e-10 3.416977e-02 pass

30000 30000 4 163.525 110.0860 8.668107e-10 3.416977e-02 pass

30000 30000 4 150.497 119.6156 8.668107e-10 3.416977e-02 pass

Performance Summary (GFlops)

Size LDA Align. Average Maximal

30000 30000 4 123.3375 128.7423

Residual checks PASSED

End of tests

## Acronyms

|  |  |
| --- | --- |
| Acronym | Meaning |
| API | Application Program Interface |
| CPU | Central Processing Unit |
| DDR3L | Double Data Rate Type 3 Low Voltage |
| DP | Double Precision |
| FLOPS | Floating Point Operations per Second |
| PAPI | Performance API |
| RAM | Random Access Memory |
| SP | Single Precision |
|  |  |
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## HWiNFO Report

A report generated by HWiNFO about the computer hardware can be found in the “HWiNFO report.txt” file.

## Bandwidth Report

A report generated by “Bandwidth” with all the results of the benchmark can be found in the “bandwidth report.txt” file. The graph generated is represented on Figure 1 - Memory benchmark results from bandwidth 1.1.

Figure 1 - Memory benchmark results from bandwidth 1.1

