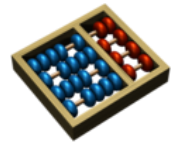




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Projeto 3

Experimental ferramentas e coletar dados

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1 Introdução

Repositório Github  <https://github.com/rubenscp/RCP-MO601-Project-03>

2 Ambiente de Experimentação

O computador utilizado em todos os experimentos está descrito conforme segue e será denominado “Laptop Rubens”:

- Notebook HP Pavilion dm4
- Memória RAM: 16 Gbytes
- SSD: 1 TBytes
- Sistema Operacional
 - Ubuntu 22.04.2 LTS (GNU/Linux 5.15.90.1-microsoft-standard-WSL2 x86_64)
- CPU:
 - Model name: Intel(R) Core(TM) i7-2620M CPU @ 2.70GHz
 - Architecture: x86_64
 - CPU op-mode(s): 32-bit, 64-bit
 - Address sizes: 36 bits physical, 48 bits virtual
 - Byte Order: Little Endian
 - CPU(s): 4
 - Vendor ID: GenuineIntel
 - CPU family: 6
 - Thread(s) per core: 2
 - Core(s) per socket: 2
 - L1d cache: 64 KiB (2 instances)
 - L1i cache: 64 KiB (2 instances)
 - L2 cache: 512 KiB (2 instances)
 - L3 cache: 4 MiB (1 instance)

3 Ferramentas experimentadas

As ferramentas utilizadas para avaliações em arquitetura de computadores foram SPEC CPU 2017, Simulador multi-core Sniper, Perf profiler, Parsec benchmark, Rodinia benchmark, Intel Pin e Dinero cache simulator. Os dados coletados para cada uma das ferramentas são apresentados nas próximas seções.

3.1 SPEC CPU 2017 benchmark *

O SPEC CPU 2017 é um pacote de benchmark que contém a próxima geração de SPECS (*Standard Performance Evaluation Corporation*), pacotes de processamento intensivo de CPU para medição e comparação de desempenho computacional, sobrecarregando o processador do sistema, memória e compilador. Esta ferramenta oferece 4 suites para benchmark considerando velocidade (*speed*) e throughput (*rate*) para números inteiros e em ponto flutuante: intspeed, fpspeed, intrate e fprate.

A Tabela 1 apresenta o resumo da experimentação do SPEC CPU 2017 no laptop Rubens com os parâmetros de execução como número de cópias, *threads*, número de iterações, tempo de execução e métrica final da execução (base). Os resultados detalhados desse experimento podem ser consultados no repositório [Github](#).

| Resultados da execução do SPEC CPU 2017 | | | | | | |
|---|--------|---------|--------------|--------------------|--------------------------------|----------------------|
| Suíte | Cópias | Threads | Nº Iterações | Qtde de Benchmarks | Tempo de execução | Métrica Final (base) |
| intspeed | 4 | 4 | 3 | 9 | 17993 s - 4,99 hs | 3,42 |
| intspeed | 8 | 8 | 3 | 10 | 18438 s – 5,12 hs | 3,35 |
| intspeed | 16 | 16 | 3 | 10 | 32523 s - 9,03 hs | 1,96 |
| intrate | 4 | 4 | 3 | 10 | 38073 s - 10,57 hs | 5,32 |
| intrate | 8 | 8 | 3 | 9 | 65121 s – 18,08 hs | 5,03 |
| fpspeed | 4 | 4 | 3 | 9 | 79708 s - 22,14 hs | 3,11 |
| fprate | 4 | 4 | 3 | 13 | 58396 s - 16,22 hs | 6,25 |
| fprate | 8 | 1 | 3 | 14 | | |
| Duração total das execuções | | | | | 310252 s – 86,18 hs | |

Tabela 1. Suites executadas na ferramenta SPEC CPU 2017 com seus parâmetros da execução, o tempo de execução e a métrica final da execução.

A Tabela 2 apresenta a comparação do computador utilizado no experimento (Laptop Rubens) e outros computadores selecionados da lista de resultados disponível no site do SPEC CPU 2017 (<https://www.spec.org/cpu2017/results/cpu2017.html>). Os computadores selecionados são aqueles que mais se aproximam das características do computador “Laptop Rubens” a fim de que as comparações das métricas finais possam ser equilibradas e justas.

| Suite | Threads | Métrica obtida do Laptop Rubens | Outros computadores | Métrica |
|----------|---------|---------------------------------|---|----------------|
| intspeed | 4 | int_base: 3,42 | SuperWorkstation 5039C-T (X11SCA , Intel Core i3-8100) | int_base: 7,58 |
| intspeed | 8 | Int_base: 3,35 | SuperWorkstation 5039C-T (X11SCA , Intel Core i7-9700K) | int_base: 10,6 |
| intspeed | 16 | int_base: 1,96 | Não localizado computador equivalente com thread = 16 | --- |
| intrate | 4 | int_base: 5,32 | ASUS Z170M-PLUS Motherboard (Intel Core i7-6700K) | int_base: 23,5 |
| intrate | 8 | int_base: 5,03 | SuperWorkstation 5039C-T (X11SCA , Intel Core i7-9700K) | int_base: 44,8 |
| fpspeed | 4 | fp_base: 3,11 | SuperWorkstation 5039C-T (X11SCA , Intel Core i7-9700K) | fp_base: 32,2 |
| fprate | 4 | fp_base: 6,25 | SuperWorkstation 5039C-T (X11SCA , Intel Core i7-9700K) | fp_base: 42,6 |
| fprate | 8 | fp_base: ??,?? | SuperWorkstation 5039C-T (X11SCA , Intel Core i7-9700K) | fp_base: 42,6 |

Tabela 2. Comparação das métricas dos benchmarks executados no laptop Rubens e outros computadores.

A Tabela 3 apresenta os comandos com os parâmetros utilizados na execução de cada uma das suítes.

| Suíte | Comando para execução do SPEC CPU 2017 |
|----------|---|
| intspeed | <code>runcpu --config=rubens-try1 --noreportable --iterations=3 600.perlbench_s 602.gcc_s 605.mcf_s 620.omnetpp_s 623.xalancbmk_s 625.x264_s 631.deepsjeng_s 641.leela_s 648.exchange2_s 998.specrand_is</code> |
| intrate | <code>runcpu --config=rubens-try1 --reportable --iterations=3 intrate</code> |

| | |
|---------|--|
| fpspeed | runcpu --config=rubens-try1 --noreportable --iterations=3 603.bwaves_s 607.cactuBSSN_s 619.lbm_s 621.wrf_s 628.pop2_s 638.imagick_s 644.nab_s 649.fotonik3d_s 654.roms_s 996.specrand_fs |
| fprate | runcpu --config=rubens-try1 --reportable --iterations=3 fprate |

Tabela 3. Comandos SPEC CPU 2017 executados para as suites inspeed, intrate, fpspeed e fprate.

3.2 Simulador multi-core Sniper *

.....

A Tabela 4 apresenta os comandos utilizados na execução dos programas bem como a indicação dos arquivos de resultados.

| Comando para execução do programa | Resultado | Arquivo com o resultado da execução |
|--|--------------------|-------------------------------------|
| make run > sniper-result-api.txt | sucesso | sniper-result-api.txt |
| make run > sniper-result-dvfs.txt | sucesso | sniper-result-dvfs.txt |
| make run > sniper-result-fft.txt | sucesso | sniper-result-fft.txt |
| make run > sniper-result-fft-dvfs.txt | sucesso | sniper-result-fft-dvfs.txt |
| make run > sniper-result-fft-hetero.txt | sucesso | sniper-result-fft-hetero.txt |
| make run > sniper-result-fft-hetero-cfg.txt | erro | sniper-result-fft-hetero-cfg.txt |
| make run > sniper-result-fft-marker.txt | erro | sniper-result-fft-marker.txt |
| make run > sniper-result-fork.txt | sucesso | sniper-result-fork.txt |
| make run > sniper-result-shared.txt | sem programa fonte | sniper-result-shared.txt |
| make run > sniper-result-signal.txt | erro | sniper-result-signal.txt |
| make run > sniper-result-smc.txt | erro | sniper-result-smc.txt |
| make run > sniper-result-sniper-in-sniper.txt | erro | sniper-result-sniper-in-sniper.txt |
| make run > sniper-result-spinloop.txt | sucesso | sniper-result-spinloop.txt |
| make run > sniper-result-true.txt | sucesso | sniper-result-true.txt |
| | | |
| Programas adicionais na pasta "extra_programs" | | |
| ../run-sniper ./RADIX > sniper-result-radix.txt | sucesso | sniper-result-RADIX |
| ../run-sniper ./CHOLESKY tk14.0 > sniper-result-cholesky.txt | sucesso | sniper-result-CHOLESKY |

Tabela 4. Comandos Sniper executados nos benchmarks do experimento.

Programas selecionados para uso avaliação mais detalhada.

| Programas selecionados | Tempo de execução no simulador Snipe "Total Time" (TSni) | Tempo de execução nativo "Total Time" (TNat) | Slowdown de simulação (TSni / TNat) |
|------------------------|--|--|-------------------------------------|
| radix | 2430 ms | 2585 ms | 0,940 |
| cholesky | 2946 ms | 5084 ms | 0,579 |
| fft | 248 ms | 376 ms | 0,659 |

- Apresentar algumas métricas de desempenho coletadas pelo simulador Sniper.
 - o Start time : -1844408187
 - o Initialization finish time : -1844371499
 - o Overall finish time : -1844369069
 - o Total time with initialization : 39118
 - o Total time without initialization : 2430

| Programas seleccionados | Sniper | | | |
|----------------------------|-----------------------------------|-------|-------------|------|
| Radix – Sniper | PROCESS STATISTICS | | | |
| | | Total | Rank | Sort |
| | Proc | Time | Time | Time |
| | 0 | 2430 | 1115 | 1315 |
| | TIMING INFORMATION | | | |
| | Start time | : | -1844408187 | |
| | Initialization finish time | : | -1844371499 | |
| | Overall finish time | : | -1844369069 | |
| | Total time with initialization | : | 39118 | |
| | Total time without initialization | : | 2430 | |
| Radix – Native | PROCESS STATISTICS | | | |
| | | Total | Rank | Sort |
| | Proc | Time | Time | Time |
| | 0 | 2585 | 742 | 1840 |
| | TIMING INFORMATION | | | |

| | Start time : 1102732390 Initialization finish time : 1102761743 Overall finish time : 1102764328 Total time with initialization : 31938 Total time without initialization : 2585 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------------------------|---|----------------|--------------------|----------------|--------------------|---|-----|----|---------|------------|---|-------------|----------------------------|---|-------------|---------------------|---|-------------|--------------------------------|---|-----|-----------------------------------|---|-----|------------------------|---|----|----------------------------|---|---------|
| cholesky | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| cholesky | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fft – Sniper | <div>PROCESS STATISTICS</div> <table><tr><th>Proc</th><th>Computation Time</th><th>Transpose Time</th><th>Transpose Fraction</th></tr><tr><td>0</td><td>248</td><td>28</td><td>0.11290</td></tr></table> <div>TIMING INFORMATION</div> <table><tr><td>Start time</td><td>:</td><td>-1844408306</td></tr><tr><td>Initialization finish time</td><td>:</td><td>-1844407925</td></tr><tr><td>Overall finish time</td><td>:</td><td>-1844407677</td></tr><tr><td>Total time with initialization</td><td>:</td><td>629</td></tr><tr><td>Total time without initialization</td><td>:</td><td>248</td></tr><tr><td>Overall transpose time</td><td>:</td><td>28</td></tr><tr><td>Overall transpose fraction</td><td>:</td><td>0.11290</td></tr></table> | Proc | Computation Time | Transpose Time | Transpose Fraction | 0 | 248 | 28 | 0.11290 | Start time | : | -1844408306 | Initialization finish time | : | -1844407925 | Overall finish time | : | -1844407677 | Total time with initialization | : | 629 | Total time without initialization | : | 248 | Overall transpose time | : | 28 | Overall transpose fraction | : | 0.11290 |
| Proc | Computation Time | Transpose Time | Transpose Fraction | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 248 | 28 | 0.11290 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Start time | : | -1844408306 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Initialization finish time | : | -1844407925 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Overall finish time | : | -1844407677 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total time with initialization | : | 629 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total time without initialization | : | 248 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Overall transpose time | : | 28 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Overall transpose fraction | : | 0.11290 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fft – Native | <div>PROCESS STATISTICS</div> <table><tr><th>Proc</th><th>Computation Time</th><th>Transpose Time</th><th>Transpose Fraction</th></tr><tr><td>0</td><td>376</td><td>61</td><td>0.16223</td></tr></table> <div>TIMING INFORMATION</div> <table><tr><td>Start time</td><td>:</td><td>-1988961673</td></tr><tr><td>Initialization finish time</td><td>:</td><td>-1988961469</td></tr><tr><td>Overall finish time</td><td>:</td><td>-1988961093</td></tr><tr><td>Total time with initialization</td><td>:</td><td>580</td></tr><tr><td>Total time without initialization</td><td>:</td><td>376</td></tr><tr><td>Overall transpose time</td><td>:</td><td>61</td></tr><tr><td>Overall transpose fraction</td><td>:</td><td>0.16223</td></tr></table> | Proc | Computation Time | Transpose Time | Transpose Fraction | 0 | 376 | 61 | 0.16223 | Start time | : | -1988961673 | Initialization finish time | : | -1988961469 | Overall finish time | : | -1988961093 | Total time with initialization | : | 580 | Total time without initialization | : | 376 | Overall transpose time | : | 61 | Overall transpose fraction | : | 0.16223 |
| Proc | Computation Time | Transpose Time | Transpose Fraction | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 376 | 61 | 0.16223 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Start time | : | -1988961673 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Initialization finish time | : | -1988961469 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Overall finish time | : | -1988961093 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total time with initialization | : | 580 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Total time without initialization | : | 376 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Overall transpose time | : | 61 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Overall transpose fraction | : | 0.16223 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

3.3 Perf profiler *

Perf profiler é uma ferramenta Linux que coleta e analisa dados de desempenho de programas ou do sistema operacional.

Os programas selecionados para avaliação são: fft, fork, signal, smc e true.

A Tabela 5 apresenta os comandos com os parâmetros utilizados na execução de cada um dos programas selecionados.

| Programa | Comando de execução |
|---|---------------------|
| fft | perf stat -B ./fft |
| Resultado da Execução | |
| <pre> FFT with Blocking Transpose 1024 Complex Doubles 1 Processors 65536 Cache lines 16 Byte line size 4096 Bytes per page PROCESS STATISTICS Computation Transpose Transpose Proc Time Time Fraction 0 303 61 0.20132 TIMING INFORMATION Start time : 695908542 Initialization finish time : 695908777 Overall finish time : 695909080 Total time with initialization : 538 Total time without initialization : 303 Overall transpose time : 61 Overall transpose fraction : 0.20132 Performance counter stats for './fft': 1.06 msec task-clock # 0.746 CPUs utilized 0 context-switches # 0.000 /sec 0 cpu-migrations # 0.000 /sec 62 page-faults # 58.701 K/sec 2540158 cycles # 2.405 GHz 1814472 stalled-cycles-frontend # 71.43% frontend cycles idle 1042654 stalled-cycles-backend # 41.05% backend cycles idle 2132716 instructions # 0.84 insn per cycle # 0.85 stalled cycles per insn 195210 branches # 184.823 M/sec 6000 branch-misses # 3.07% of all branches 0.001415500 seconds time elapsed 0.001717000 seconds user 0.000000000 seconds sys </pre> | |

| Programa | Comando de execução |
|--|--|
| fft | perf stat -B ./fft if=/dev/zero of=/dev/null count=1000000 |
| Resultado da Execução | |
| <pre> FFT with Blocking Transpose 1024 Complex Doubles 1 Processors 65536 Cache lines 16 Byte line size 4096 Bytes per page PROCESS STATISTICS Computation Transpose Transpose Proc Time Time Fraction 0 335 59 0.17612 TIMING INFORMATION Start time : 760328360 Initialization finish time : 760328587 Overall finish time : 760328922 Total time with initialization : 562 Total time without initialization : 335 Overall transpose time : 59 Overall transpose fraction : 0.17612 Performance counter stats for './fft if=/dev/zero of=/dev/null count=1000000': 1.01 msec task-clock # 0.731 CPUs utilized 0 context-switches # 0.000 /sec 0 cpu-migrations # 0.000 /sec 62 page-faults # 61.198 K/sec 2561675 cycles # 2.529 GHz 1839401 stalled-cycles-frontend # 71.80% frontend cycles idle 1031193 stalled-cycles-backend # 40.25% backend cycles idle 2135867 instructions # 0.83 insn per cycle # 0.86 stalled cycles per insn 195848 branches # 193.316 M/sec 5650 branch-misses # 2.88% of all branches 0.001386500 seconds time elapsed 0.001920000 seconds user 0.000000000 seconds sys </pre> | |
| Programa | Comando de execução |
| fork | perf stat -B ./fork |
| Resultado da Execução | |
| <pre> Hello world from parent Hello world from child Performance counter stats for './fork': 0.94 msec task-clock # 0.045 CPUs utilized 2 context-switches # 2.139 K/sec 0 cpu-migrations # 0.000 /sec 55 page-faults # 58.811 K/sec 1820753 cycles # 1.947 GHz 1528003 stalled-cycles-frontend # 83.92% frontend cycles idle 1222034 stalled-cycles-backend # 67.12% backend cycles idle 578101 instructions # 0.32 insn per cycle # 2.64 stalled cycles per insn 118406 branches # 126.610 M/sec 6079 branch-misses # 5.13% of all branches 0.020806800 seconds time elapsed </pre> | |

| 0.001550000 seconds user 0.000000000 seconds sys | |
|--|-----------------------|
| Programa | Comando de execução |
| signal | perf stat -B ./signal |
| Resultado da Execução | |
| <pre> Installing signal handler Dereferencing NULL pointer Received signal 11 Performance counter stats for './signal': 0.45 msec task-clock # 0.545 CPUs utilized 0 context-switches # 0.000 /sec 0 cpu-migrations # 0.000 /sec 30 page-faults # 66.800 K/sec 978289 cycles # 2.178 GHz 798099 stalled-cycles-frontend # 81.58% frontend cycles idle 634507 stalled-cycles-backend # 64.86% backend cycles idle 350129 instructions # 0.36 insn per cycle # 2.28 stalled cycles per insn 70957 branches # 157.998 M/sec 3626 branch-misses # 5.11% of all branches 0.000824699 seconds time elapsed 0.000910000 seconds user 0.000000000 seconds sys </pre> | |
| Programa | Comando de execução |
| smc | perf stat -B ./smc |
| Resultado da Execução | |
| <pre> Good morning! Performance counter stats for './smc': 0.47 msec task-clock # 0.588 CPUs utilized 0 context-switches # 0.000 /sec 0 cpu-migrations # 0.000 /sec 29 page-faults # 61.259 K/sec 1070708 cycles # 2.262 GHz 842947 stalled-cycles-frontend # 78.73% frontend cycles idle 621900 stalled-cycles-backend # 58.08% backend cycles idle 493319 instructions # 0.46 insn per cycle # 1.71 stalled cycles per insn 92454 branches # 195.298 M/sec 3768 branch-misses # 4.08% of all branches 0.000805700 seconds time elapsed 0.000894000 seconds user 0.000000000 seconds sys </pre> | |
| Programa | Comando de execução |
| true | perf stat -B ./true |
| Resultado da Execução | |
| <pre> Performance counter stats for './true': 0.48 msec task-clock # 0.548 CPUs utilized 0 context-switches # 0.000 /sec 0 cpu-migrations # 0.000 /sec 28 page-faults # 58.700 K/sec 855835 cycles # 1.794 GHz </pre> | |

```

697077      stalled-cycles-frontend    #    81.45% frontend cycles idle
536036      stalled-cycles-backend    #    62.63% backend cycles idle
323449      instructions               #    0.38  insn per cycle
#    2.16  stalled cycles per insn
64571       branches                  #   135.369 M/sec
3028        branch-misses             #    4.69% of all branches

0.000870500 seconds time elapsed

0.000992000 seconds user
0.000000000 seconds sys

```

Tabela 5. Comandos Perf profiler executados nos programas selecionados no experimento.

- Incluir os programas RADIX e
 - perf stat -B ./RADIX
 - perf stat -B ./CHOLESKY tk14.O
-
- Extrair as mesmas métricas do Sniper de forma nativa
 - Comparar as métricas do Perf com as do Sniper
 - Justificar as diferenças

3.4 PARSEC Benchmark Suite 3.0 *

O PARSEC (*Princeton Application Repository for Shared-Memory Computers*) é um conjunto de benchmark composto por programas *multithread* com o propósito de possibilitar estudos de desempenho em computadores com múltiplos processadores.

A Tabela 6 apresenta a compilação dos pacotes de benchmark oferecidos no PARSEC com o resultado indicando sucesso ou os erros apresentados no processo de compilação (build).

| Pacote | Comando para compilação | Resultado |
|--------------|-------------------------------------|---|
| blackscholes | parsecmgmt -a build -p blackscholes | Compilou com sucesso. |
| bodytrack | parsecmgmt -a build -p bodytrack | Compilou com sucesso. |
| facesim | parsecmgmt -a build -p facesim | make[2]: *** [/usr/local/parsec-3.0/pkgs/apps/facesim/obj/amd64-linux.gcc/Public_Library/Makefile.common:407: obj/Collisions_And_Interactions/COLLISION_BODY_LIST_3D.o] Error 1 make[2]: Leaving directory '/usr/local/parsec-3.0/pkgs/apps/facesim/obj/amd64-linux.gcc/Public_Library' make[1]: *** No rule to make target '/usr/local/parsec-3.0/pkgs/apps/facesim/obj/amd64-linux.gcc/lib/libPhysBAM.a', needed by 'facesim'. Stop. make[1]: Leaving directory '/usr/local/parsec-3.0/pkgs/apps/facesim/obj/amd64-linux.gcc/Benchmarks/facesim' make: *** [Makefile:16: all] Error 2 [PARSEC] Error: 'env version=threads PHYSBAM=/usr/local/parsec-3.0/pkgs/apps/facesim/obj/amd64-linux.gcc CXXFLAGS=-O3 -g -funroll-loops -fprefetch-loop-arrays -fpermissive -fno-exceptions -std=c++11 -static-libgcc -Wl,--hash-style=both,--as-needed -DPARSEC_VERSION=3.0-beta-20150206 -fexceptions /usr/bin/make' failed. |
| ferret | parsecmgmt -a build -p ferret | make: *** [Makefile:108: /usr/local/parsec-3.0/pkgs/apps/ferret/obj/amd64-linux.gcc/parsec/obj/LSH_query.o] Error 1 [PARSEC] Error: 'env version=threads CFLAGS=-I/usr/local/parsec-3.0/pkgs/libs/gsl/inst/amd64-linux.gcc/include -I/usr/local/parsec-3.0/pkgs/libs/libjpeg/inst/amd64-linux.gcc/include -O3 -g -funroll-loops -fprefetch-loop-arrays -static-libgcc -Wl,--hash-style=both,--as-needed -DPARSEC_VERSION=3.0-beta-20150206 LDFLAGS=-L/usr/local/parsec-3.0/pkgs/libs/gsl/inst/amd64-linux.gcc/lib -L/usr/local/parsec-3.0/pkgs/libs/libjpeg/inst/amd64-linux.gcc/lib -L/usr/lib64 -L/usr/lib /usr/bin/make' failed. |
| fluidanimate | parsecmgmt -a build -p fluidanimate | Compilou com sucesso. |
| freqmine | parsecmgmt -a build -p freqmine | Compilou com sucesso. |
| raytrace | parsecmgmt -a build -p raytrace | No package 'xext' found Consider adjusting the PKG_CONFIG_PATH environment variable if you installed software in a non-standard prefix. Alternatively, you may set the environment variables XLIBGL_CFLAGS and XLIBGL_LIBS to avoid the need to call pkg-config. See the pkg-config man page for more details. [PARSEC] Error: 'env ./configure --with-driver=xlib --enable-glut --enable-static --disable-shared --prefix=/usr/local/parsec-3.0/pkgs/libs/mesa/inst/amd64-linux.gcc' failed. |
| swaptions | parsecmgmt -a build -p swaptions | ~~~~~ make[1]: *** [../build/Makefile.tbmalloc:70: proxy.o] Error 1 make[1]: Leaving directory '/usr/local/parsec-3.0/pkgs/libs/tbllib/obj/amd64-linux.gcc/build/linux_intel64_gcc_cc11.3.0_libc2.35_kernel5.15.90.1_debug' make: *** [Makefile:49: tbmalloc] Error 2 [PARSEC] Error: 'env compiler=gcc PATH=/usr/bin:/usr/local/parsec-3.0/bin:/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/snap/bin' |

| | | |
|------|-----------------------------|--|
| | | n:/usr/local/parsec-3.0/bin CXXFLAGS=-O3 -g -funroll-loops -fprefetch-loop-arrays -fpermissive -fno-exceptions -static-libgcc -Wl,--hash-style=both,--as-needed -DPARSEC_VERSION=3.0-beta-20150206 -fexceptions /usr/bin/make' failed. |
| vips | parsecmgmt -a build -p vips | Compilou com sucesso. |

Tabela 6. Resultado da compilação dos pacotes do PARSEC.

O PARSEC possibilita definir a região de interesse (ROI – *Region Of Interest*) baseada em seis tipos de entrada possíveis na execução dos benchmarks. As entradas são: test, simdev, simsmall, simmedium, simlarge e native.

Os testes realizados no experimento utilizaram todas as entradas nos benchmarks executados, cujos comandos de execução e indicação dos resultados são apresentados na Tabela 7 que segue. As saídas da execução estão armazenadas nos arquivos com extensão “txt”.

EXPLORAR O PARALELISMO –N

parsecmgmt -a run -p fluidanimate -i native -n 16

parsecmgmt -a run -p blackscholes -i native -n 16

parsecmgmt -a run -p freqmine -i native -n 16

parsecmgmt -a run -p vips -i native -n 16

parsecmgmt -a run -p fluidanimate -i native -n 8

parsecmgmt -a run -p blackscholes -i native -n 8

parsecmgmt -a run -p freqmine -i native -n 8

parsecmgmt -a run -p vips -i native -n 8

parsecmgmt -a run -p fluidanimate -i native -n 4

parsecmgmt -a run -p blackscholes -i native -n 4

parsecmgmt -a run -p freqmine -i native -n 4

parsecmgmt -a run -p vips -i native -n 4

parsecmgmt -a run -p fluidanimate -i native -n 2

parsecmgmt -a run -p blackscholes -i native -n 2

parsecmgmt -a run -p freqmine -i native -n 2

parsecmgmt -a run -p vips -i native -n 2

parsecmgmt -a run -p fluidanimate -i native

parsecmgmt -a run -p blackscholes -i native

parsecmgmt -a run -p freqmine -i native

parsecmgmt -a run -p vips -i native

| Núm. da Execução | Pacote | Entrada | Comando de execução do pacote de Benchmark |
|------------------|--------------|----------|---|
| 001 | blackscholes | test | parsecmgmt -a run -p blackscholes -i test > result/exec-001-blackscholes-test.txt |
| 002 | blackscholes | simdev | parsecmgmt -a run -p blackscholes -i simdev > result/exec-002-blackscholes-simdev.txt |
| 003 | blackscholes | simsmall | parsecmgmt -a run -p blackscholes -i simsmall > result/exec-003-blackscholes-simsmall.txt |
| 004 | blackscholes | simlarge | parsecmgmt -a run -p blackscholes -i simlarge > result/exec-004-blackscholes-simlarge.txt |
| 005 | blackscholes | native | parsecmgmt -a run -p blackscholes -i native > result/exec-005-blackscholes-native.txt |
| 006 | vips | test | parsecmgmt -a run -p vips -i test > result/exec-006-vips-test.txt |
| 007 | vips | simdev | parsecmgmt -a run -p vips -i simdev > result/exec-007-vips-simdev.txt |
| 008 | vips | simsmall | parsecmgmt -a run -p vips -i simsmall > result/exec-008-vips-simsmall.txt |
| 009 | vips | simlarge | parsecmgmt -a run -p vips -i simlarge > result/exec-009-vips-simlarge.txt |
| 010 | vips | native | parsecmgmt -a run -p vips -i native > result/exec-010-vips-native.txt |
| 011 | bodytrack | test | parsecmgmt -a run -p bodytrack -i test > result/exec-011-bodytrack-test.txt |
| 012 | bodytrack | simdev | parsecmgmt -a run -p bodytrack -i simdev > result/exec-012-bodytrack-simdev.txt |
| 013 | bodytrack | simsmall | parsecmgmt -a run -p bodytrack -i simsmall > result/exec-013-bodytrack-simsmall.txt |
| 014 | bodytrack | simlarge | parsecmgmt -a run -p bodytrack -i simlarge > result/exec-014-bodytrack-simlarge.txt |
| 015 | bodytrack | native | parsecmgmt -a run -p bodytrack -i native > result/exec-015-bodytrack-native.txt |
| 016 | fluidanimate | test | parsecmgmt -a run -p fluidanimate -i test > result/exec-016-fluidanimate-test.txt |
| 017 | fluidanimate | simdev | parsecmgmt -a run -p fluidanimate -i simdev > result/exec-017-fluidanimate-simdev.txt |
| 018 | fluidanimate | simsmall | parsecmgmt -a run -p fluidanimate -i simsmall > result/exec-018-fluidanimate-simsmall.txt |
| 019 | fluidanimate | simlarge | parsecmgmt -a run -p fluidanimate -i simlarge > result/exec-019-fluidanimate-simlarge.txt |
| 020 | fluidanimate | native | parsecmgmt -a run -p fluidanimate -i native > result/exec-020-fluidanimate-native.txt |

| | | | |
|-----|----------|----------|---|
| 021 | freqmine | test | parsecmgmt -a run -p freqmine -i test > result/exec-021-freqmine-test.txt |
| 022 | freqmine | simdev | parsecmgmt -a run -p freqmine -i simdev > result/exec-022-freqmine-simdev.txt |
| 023 | freqmine | simsmall | parsecmgmt -a run -p freqmine -i simsmall > result/exec-023-freqmine-simsmall.txt |
| 024 | freqmine | simlarge | parsecmgmt -a run -p freqmine -i simlarge > result/exec-024-freqmine-simlarge.txt |
| 025 | freqmine | native | parsecmgmt -a run -p freqmine -i native > result/exec-025-freqmine-native.txt |
| 026 | splash2 | test | parsecmgmt -a run -p splash2 -i test > result/exec-026-splash2-test.txt |
| 027 | splash2 | simdev | parsecmgmt -a run -p splash2 -i simdev > result/exec-027-splash2-simdev.txt |
| 028 | splash2 | simsmall | parsecmgmt -a run -p splash2 -i simsmall > result/exec-028-splash2-simsmall.txt |
| 029 | splash2 | simlarge | parsecmgmt -a run -p splash2 -i simlarge > result/exec-029-splash2-simlarge.txt |
| 030 | splash2 | native | parsecmgmt -a run -p splash2 -i native > result/exec-030-splash2-native.txt |
| 031 | splash2x | test | parsecmgmt -a run -p splash2x -i test > result/exec-031-splash2x-test.txt |
| 032 | splash2x | simdev | parsecmgmt -a run -p splash2x -i simdev > result/exec-032-splash2x-simdev.txt |
| 033 | splash2x | simsmall | parsecmgmt -a run -p splash2x -i simsmall > result/exec-033-splash2x-simsmall.txt |
| 034 | splash2x | simlarge | parsecmgmt -a run -p splash2x -i simlarge > result/exec-034-splash2x-simlarge.txt |
| 035 | splash2x | native | parsecmgmt -a run -p splash2x -i native > result/exec-035-splash2x-native.txt |

Tabela 7. Comandos PARSEC para execução dos benchmarks com as entradas possíveis.

Fazer um gráfico quatro aplicações, variando o valor de N no eixo X e o tempo real no Y. Usar N=1 a referencia (baseline)

3.5 Rodinia benchmark *

O Rodinia Benchmark é uma ferramenta destinada a infraestrutura de computação heterogênea com implementações com OpenMP, OpenCL e CUDA.

A Tabela 8 apresenta a lista dos programas que foram compilados com sucesso em cada implementação.

| CUDA (make CUDA) | OPENMP (make OMP) | OPENCL (make OPENCL) |
|------------------|-------------------|---------------------------|
| <u>backprop</u> | backprop | OCL_particlefilter_double |

| | | |
|-------------------|------------------------|---------------------------|
| <u>bfs</u> | bfs | OCL_particlefilter_naive |
| <u>dwt2d</u> | euler3d_cpu | OCL_particlefilter_single |
| <u>gaussian</u> | euler3d_cpu_double | backprop |
| <u>heartwall</u> | heartwall | gaussian |
| <u>hotspot</u> | hotspot | heartwall |
| <u>kmeans</u> | kmeans | hotspot |
| <u>leukocyte</u> | lavaMD | kmeans |
| <u>needle</u> | leukocyte | lavaMD |
| <u>nn</u> | lud_omp | leukocyte |
| <u>pathfinder</u> | needle | lud |
| <u>sc_gpu</u> | nn | nn |
| <u>srad_v1</u> | particle_filter | nw |
| <u>srad_v2</u> | pathfinder | srad |
| | pre_euler3d_cpu | |
| | pre_euler3d_cpu_double | |
| | sc_omp | |
| | srad_v1 | |
| | srad_v2 | |

Tabela 8. Lista de programas que foram compilados com sucesso no ambiente da ferramenta Rodinia Benchmark.

A Tabela 9 apresenta a execução de benchmarks com alguns resultados detalhados ou o nome do arquivo de resultado devido ao seu tamanho excessivo.

| Implementação | Benchmark | Resultado |
|----------------------|------------------|---|
| OPENMP | bfs | result.txt |
| OPENMP | cfid (euler3d) | 409.637 segundos root@NotebookRubens:/usr/local/rodinia_3.1/openmp/cfid# ./run Starting... Compute time: 409.637 Saving solution... Saved solution... Cleaning up... Done... |
| OPENMP | heartwall | result.txt |
| OPENMP | hotspot | output.out |
| OPENMP | kmeans | root@NotebookRubens:/usr/local/rodinia_3.1/openmp/kmeans# ./run ./run: line 1: ./kmeans_serial/kmeans: No such file or directory I/O completed num of threads = 4 number of Clusters 5 number of Attributes 34 Time for process: 4.266001 |
| OPENMP | lavaMD | root@NotebookRubens:/usr/local/rodinia_3.1/openmp/lavaMD# ./run Configuration used: cores = 4, boxes1d = 10 Time spent in different stages of CPU/MCPU KERNEL: 0.000000000000 s, 0.000000000000 % : CPU/MCPU: VARIABLES 0.000014000000 s, 0.000279933040 % : MCPU: SET DEVICE 0.000000000000 s, 0.000000000000 % : CPU/MCPU: INPUTS 5.001182079315 s, 99.999717712402 % : CPU/MCPU: KERNEL Total time: 5.001195907593 s |
| OPENMP | leukocyte | root@NotebookRubens:/usr/local/rodinia_3.1/openmp/leukocyte# ./run Num of threads: 4 Detecting cells in frame 0 |

| | | |
|--------|-----------------|---|
| | | <p>Cells detected: 36</p> <p>Detection runtime -----</p> <p>GICOV computation: 0.52551 seconds GICOV dilation: 0.21413 seconds Total: 0.79247 seconds</p> <p>Tracking cells across 5 frames Processing frame 5 / 5</p> <p>Tracking runtime (average per frame): -----</p> <p>MGVF computation: 14.68158 seconds Snake evolution: 0.02456 seconds Total: 4.09308 seconds</p> <p>Total application run time: 21.25787 seconds</p> |
| OPENMP | nn | <p>root@NotebookRubens:/usr/local/rodinia_3.1/openmp/nn# ./run</p> <p>The 5 nearest neighbors are:</p> <p>1974 12 22 18 24 JOYCE 30.6 89.9 80 593 --> 0.608276 2003 8 27 12 10 TONY 29.9 89.4 160 286 --> 0.608275 1997 11 14 12 24 HELENE 30.5 89.8 134 529 --> 0.538515 1980 10 22 18 3 ISAAC 30.1 90.4 110 778 --> 0.412312 1988 12 27 0 18 TONY 30.0 89.8 113 39 --> 0.199997 total time : 0.527607023716 s</p> |
| OPENMP | particle_filter | Result.txt |
| OPENMP | pathfinder | o.out |
| OPENMP | srاد_v1 | <p>root@NotebookRubens:/usr/local/rodinia_3.1/openmp/srad/srad_v1# ./run</p> <p>Time spent in different stages of the application:</p> <p>0.000000000000 s, 0.000000000000 % : SETUP VARIABLES 0.000021000000 s, 0.001276622177 % : READ COMMAND LINE PARAMETERS 0.131821006536 s, 8.013600349426 % : READ IMAGE FROM FILE 0.002430000110 s, 0.147723421454 % : RESIZE IMAGE 0.000082999999 s, 0.005045697093 % : SETUP, MEMORY ALLOCATION 0.016366999596 s, 0.994974911213 % : EXTRACT IMAGE 1.328287959099 s, 80.748657226562 % : COMPUTE 0.005131000187 s, 0.311921358109 % : COMPRESS IMAGE 0.160110995173 s, 9.733392715454 % : SAVE IMAGE INTO FILE 0.000714000023 s, 0.043405152857 % : FREE MEMORY Total time: 1.644966006279 s</p> |
| OPENMP | srاد_v2 | <p>root@NotebookRubens:/usr/local/rodinia_3.1/openmp/srad/srad_v2# ./run</p> <p>Randomizing the input matrix Start the SRAD main loop Computation Done</p> |

Tabela 9. Benchmarks executados com os resultados.

A Tabela 10 apresenta comparações de alguns benchmarks que foram executados nas três implementações CUDA, OpenMP e OpenCL.

Comparação de Benchmarks entre as Implementações CUDA, OpenMP e OpenCL

| Hotspot | | |
|--|---|---|
| CUDA | OpenMP | OpenCL |
| root@NotebookRubens:/usr/local/rodinia_3.1/cuda/hotspot# ./run WG size of kernel = 16 X 16 pyramidHeight: 2 gridSize: [512, 512] border:[2, 2] blockGrid:[43, 43] targetBlock:[12, 12] Start computing the transient temperature Ending simulation | root@NotebookRubens:/usr/local/rodinia_3.1/openmp/hotspot# ./run Start computing the transient temperature Ending simulation Total time: 0.045 seconds | Erro de execução |
| BFS | | |
| CUDA | OpenMP | OpenCL |
| root@NotebookRubens:/usr/local/rodinia_3.1/cuda/bfs# ./run Reading File Read File Copied Everything to GPU memory Start traversing the tree Kernel Executed 1 times Result stored in result.txt >> 1.000.000 lines | root@NotebookRubens:/usr/local/rodinia_3.1/openmp/bfs# ./run Reading File Start traversing the tree Compute time: 0.633491 Result stored in result.txt >> 1.000.000 lines | Erro de compilação |
| HeartWall | | |
| CUDA | OpenMP | OpenCL |
| root@NotebookRubens:/usr/local/rodinia_3.1/cuda/heartwall# ./run WG size of kernel = 256 frame progress: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 Resultados no arquivo result.txt | root@NotebookRubens:/usr/local/rodinia_3.1/openmp/heartwall# ./run num of threads: 4 frame progress: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 Resultados no arquivo result.txt | Erro de execução |
| particlefilter | | |
| CUDA | OpenMP | OpenCL |
| Erro de compilação | video sequence took 0.043539 time to get neighbors took: 0.000005 time to get weightstook: 0.014813 time to set arrays took: 0.000106 time to set error took: 0.000682 time to get likelihoods took: 0.002394 time to get exp took: 0.000109 time to sum weights took: 0.000008 time to normalize weights took: 0.000004 time to move object took: 0.000008 xe: 64.523185 ye: 64.469547 0.702991 ... time to calc cum sum took: 0.000033 time to calc u took: 0.011697 time to calc new array x and y took: 0.061382 time to reset weights took: 0.000047 time to set error took: 0.006374 time to get likelihoods took: 0.008245 time to get exp took: 0.011114 time to sum weights took: 0.011051 time to normalize weights took: 0.008430 time to move object took: 0.016451 xe: 48.546698 ye: 72.385056 17.581630 time to calc cum sum took: 0.000034 time to calc u took: 0.013806 time to calc new array x and y took: 0.053608 time to reset weights took: 0.000045 particle filter took 0.937339 | root@notebookrubens:/usr/local/rodinia_3.1/opencl/particlefilter# ./run video sequence took 0.063222 error: clgetplatformids(1,*,0) failed particle filter took 0.694592 entire program took 0.757814 video sequence took 0.031961 error: clgetplatformids(1,*,0) failed particle filter took 0.632983 entire program took 0.664944 |

| | | |
|--|------------------------------|--|
| | entire program took 0.980878 | |
|--|------------------------------|--|

Tabela 10. Comparação de benchmarks nas três implementações CUDA, OpenMP e OpenCL.

- Se tiver hardware suficiente, rodar as múltiplas versões do programa e comparar o desempenho no mesmo computador.
- Para múltiplas configurações do mesmo programa, indicar as diferenças de desempenho.
- Executar o Rodinia nos três programas abaixo e comparar o desempenho:
 - RADIX
 - CHOLESKY
 - FFT

3.6 Intel Pin

- ➔ Aguardando definição dos 3 programas para experimentos posteriores
- ➔ Executar o Pin nos três programas abaixo e comparar o desempenho utilizando a ferramenta do “PinTools” (opcodemix) aplicado aos três programas abaixo
 - RADIX
 - CHOLESKY
 - FFT

3.7 Dinero cache simulator

A ferramenta Dinero é um simulador de cache de 4ª geração de simuladores.

Os programas utilizados nessa ferramenta foram o RADIX e o fft. Vários parâmetros foram avaliados considerando valores distintos para cache L1 (instrução e data), combinados com cache L2 e L3 (unificadas).

A Tabela 11 apresenta os comandos utilizados na execução dos programas RADIX e fft com os diversos parâmetros de execução relacionados às caches L1, L2 e L3.

| Programa RADIX | |
|--|-------------------------------------|
| Comando de execução | Arquivo com o resultado da execução |
| ./dineroIV-tar -l1-isize 1k -l1-dsize 1k -l1-ibsize 32 -l1-dbsize 32 -informat p < RADIX > dinero-result-RADIX-001.txt | dinero-result-RADIX-001.txt |
| ./dineroIV-tar -l1-isize 2k -l1-dsize 2k -l1-ibsize 16 -l1-dbsize 16 -informat p < RADIX > dinero-result-RADIX-002.txt | dinero-result-RADIX-002.txt |
| ./dineroIV-tar -l1-isize 4k -l1-dsize 4k -l1-ibsize 8 -l1-dbsize 8 informat p < RADIX > dinero-result-RADIX-003.txt | dinero-result-RADIX-003.txt |
| ./dineroIV-tar -l1-isize 8k -l1-dsize 8k -l1-ibsize 4 -l1-dbsize 4 informat p < RADIX > dinero-result-RADIX-004.txt | dinero-result-RADIX-004.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -informat p < RADIX > dinero-result-RADIX-005.txt | dinero-result-RADIX-005.txt |
| ./dineroIV-tar -l1-isize 32k -l1-dsize 32k -l1-ibsize 1 -l1-dbsize 1 -informat p < RADIX > dinero-result-RADIX-006.txt | dinero-result-RADIX-006.txt |
| ./dineroIV-tar -l1-isize 1k -l1-dsize 1k -l1-ibsize 32 -l1-dbsize 32 -l1-iassoc 8 -l1- dassoc 8 -informat p < RADIX > dinero-result-RADIX-007.txt | dinero-result-RADIX-007.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -informat p < RADIX > dinero-result-RADIX-008.txt | dinero-result-RADIX-008.txt |
| ./dineroIV-tar -l1-isize 32k -l1-dsize 32k -l1-ibsize 1 -l1-dbsize 1 -l1-iassoc 8 -l1- dassoc 8 -informat p < RADIX > dinero-result-RADIX-009.txt | dinero-result-RADIX-009.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 512k -l2-ubsize 1 -informat p < RADIX > dinero- result-RADIX-010.txt | dinero-result-RADIX-010.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 256k -l2-ubsize 2 -informat p < RADIX > dinero- result-RADIX-011.txt | dinero-result-RADIX-011.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 128k -l2-ubsize 4 -informat p < RADIX > dinero- result-RADIX-012.txt | dinero-result-RADIX-012.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 128k -l2-ubsize 4 -l2-uassoc 8 -l3-usize 1m -l3-ubsize 4 -l3- uassoc 8 -informat p < RADIX > dinero-result-RADIX-013.txt | dinero-result-RADIX-013.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 128k -l2-ubsize 4 -l2-uassoc 8 -l3-usize 2m -l3-ubsize 4 -l3- uassoc 8 -informat p < RADIX > dinero-result-RADIX-014.txt | dinero-result-RADIX-014.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 128k -l2-ubsize 4 -l2-uassoc 8 -l3-usize 4m -l3-ubsize 1 -l3- uassoc 8 -informat p < RADIX > dinero-result-RADIX-015.txt | dinero-result-RADIX-015.txt |

| Programa FFT | |
|--|-------------------------------------|
| Comando de execução | Arquivo com o resultado da execução |
| ./dineroIV-tar -l1-isize 1k -l1-dsize 1k -l1-ibsize 32 -l1-dbsize 32 -informat p < fft > dinero-result-fft-001.txt | dinero-result-fft-001.txt |
| ./dineroIV-tar -l1-isize 2k -l1-dsize 2k -l1-ibsize 16 -l1-dbsize 16 -informat p < fft > dinero-result-fft-002.txt | dinero-result-fft-002.txt |
| ./dineroIV-tar -l1-isize 4k -l1-dsize 4k -l1-ibsize 8 -l1-dbsize 8 informat p < fft > dinero-result-fft-003.txt | dinero-result-fft-003.txt |
| ./dineroIV-tar -l1-isize 8k -l1-dsize 8k -l1-ibsize 4 -l1-dbsize 4 informat p < fft > dinero-result-fft-004.txt | dinero-result-fft-004.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -informat p < fft > dinero-result-fft-005.txt | dinero-result-fft-005.txt |
| ./dineroIV-tar -l1-isize 32k -l1-dsize 32k -l1-ibsize 1 -l1-dbsize 1 -informat p < fft > dinero-result-fft-006.txt | dinero-result-fft-006.txt |
| ./dineroIV-tar -l1-isize 1k -l1-dsize 1k -l1-ibsize 32 -l1-dbsize 32 -l1-iassoc 8 -l1- dassoc 8 -informat p < fft > dinero-result-fft-007.txt | dinero-result-fft-007.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -informat p < fft > dinero-result-fft-008.txt | dinero-result-fft-008.txt |
| ./dineroIV-tar -l1-isize 32k -l1-dsize 32k -l1-ibsize 1 -l1-dbsize 1 -l1-iassoc 8 -l1- dassoc 8 -informat p < fft > dinero-result-fft-009.txt | dinero-result-fft-009.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 512k -l2-ubsize 1 -informat p < fft > dinero-result- fft-010.txt | dinero-result-fft-010.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 256k -l2-ubsize 2 -informat p < fft > dinero-result- fft-011.txt | dinero-result-fft-011.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 128k -l2-ubsize 4 -informat p < fft > dinero-result- fft-012.txt | dinero-result-fft-012.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 128k -l2-ubsize 4 -l2-uassoc 8 -l3-usize 1m -l3-ubsize 4 -l3- uassoc 8 -informat p < fft > dinero-result-fft-013.txt | dinero-result-fft-013.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 128k -l2-ubsize 4 -l2-uassoc 8 -l3-usize 2m -l3-ubsize 4 -l3- uassoc 8 -informat p < fft > dinero-result-fft-014.txt | dinero-result-fft-014.txt |
| ./dineroIV-tar -l1-isize 16k -l1-dsize 16k -l1-ibsize 2 -l1-dbsize 2 -l1-iassoc 8 -l1- dassoc 8 -l2-usize 128k -l2-ubsize 4 -l2-uassoc 8 -l3-usize 4m -l3-ubsize 1 -l3- uassoc 8 -informat p < fft > dinero-result-fft-015.txt | dinero-result-fft-015.txt |

Tabela 11. Comandos Dinero para execução dos programas RADIX e FFT com variados parâmetros de execução relacionados às caches L1, L2 e L3.

4 Considerações sobre o aprendizado nesse projeto

5 Conclusões