Lista 6 - Medição correta do Speed up

A função “cpu_time()” não é adequada para o nosso objetivo:

“cpu_time adds up the time spent by all the threads”
https://software.intel.com/en-us/forums/intel-fortran-compiler/topic/281897

“cpu_time() is not suitable to measure the performance of multi-threaded code. cpu_time() will add the total time of all the threads which is likely to increase with increasing number of threads.”
https://stackoverflow.com/questions/15362966/fortran-openmp-more-slow-that-sequential

Usando a função “omp_get_wtime()”:

VERSÃO PARALELA

```
program list06p
! CAP372 - exercise 06 - parallel version - 2019-09-21
! integration of pi : 4.0/(1+x*) dx, interval: 0 to hs
! gfortran -Og -Wall -fcheck=all -fopenmp -o list06p list06p.f90
! gfortran -fopenmp -o list06p list06p.f90
! ./list06p
  use omp_lib
  implicit none
  integer :: n, t
  n=2**26
  t=2
  call calc(n, t)
  t=3
  call calc(n, t)
  t=4
  call calc(n, t)
  n=2**28
  t=2
  call calc(n, t)
  t=3
  call calc(n, t)
  t=4
  call calc(n, t)
  n=2**30
  t=2
  call calc(n, t)
  t=3
  call calc(n, t)
  t=4
  call calc(n, t)
contains
  subroutine calc(n, t)
    integer, intent(in) :: n, t
    double precision, parameter  :: a=0.0, b=1.0
    double precision :: pi, t1, t2, x, h, integral=0.0
    integer :: i
    t1 = omp_get_wtime()
    integral = ( ( 4.0 / ( 1.0 + a * a ) ) +  &
                 ( 4.0 / ( 1.0 + b * b ) ) ) / 2.0
    x = a
    h = ( b - a ) / n
!$omp parallel do private(x) reduction(+:integral) num_threads(t)
    do i = 1, n - 1
      x = a + h * i
      integral = integral + 4.0 / (1.0 + x * x)
    end do
!$omp end parallel do
    pi = integral * h
    t2 = omp_get_wtime()
    print*, "Partitions:", n,"    Threads:", t
    print*, "Result:", pi, "    Error:", dacos(-1.d0) - pi
    print*, "Elapsed time:", t2 - t1
    print*, ""
  end subroutine
end program list06p
```

RESULTADO

```
$ gfortran -fopenmp -o list06p list06p.f90
$ ./list06p
 Partitions:    67108864     Threads:           2
 Result:   3.1415926535892620          Error:   5.3113069498067489E-013
 Elapsed time:  0.42782379799973569

 Partitions:    67108864     Threads:           3
 Result:   3.1415926535899472          Error:  -1.5409895581797173E-013
 Elapsed time:  0.28681157699975302

 Partitions:    67108864     Threads:           4
 Result:   3.1415926535894423          Error:   3.5083047578154947E-013
 Elapsed time:  0.22577948499747436
```

```
 Partitions:   268435456     Threads:           2
 Result:   3.1415926535900667          Error:  -2.7355895326763857E-013
 Elapsed time:   1.6969807259993104

 Partitions:   268435456     Threads:           3
 Result:   3.1415926535899752          Error:  -1.8207657603852567E-013
 Elapsed time:   1.1460634920003940

 Partitions:   268435456     Threads:           4
 Result:   3.1415926535901377          Error:  -3.4461322684364859E-013
 Elapsed time:  0.89091836199804675

 Partitions:  1073741824     Threads:           2
 Result:   3.1415926535899747          Error:  -1.8163248682867561E-013
 Elapsed time:   6.7740604739992705

 Partitions:  1073741824     Threads:           3
 Result:   3.1415926535897745          Error:   1.8651746813702630E-014
 Elapsed time:   4.6008846500008076

 Partitions:  1073741824     Threads:           4
 Result:   3.1415926535898269          Error:  -3.3750779948604759E-014
 Elapsed time:   3.6927661669978988
```

VERSÃO SÉRIE

```
program list06s
! CAP372 - exercise 06 - serial version - 2019-09-21
! integration of pi : 4.0/(1+x*) dx, interval: 0 to hs
! gfortran -Og -Wall -fcheck=all -fopenmp -o list06p list06p.f90
! gfortran -fopenmp -o list06s list06s.f90
! ./list06s
  use omp_lib
  implicit none
  integer :: n
  n=2**26
  call calc(n)
  n=2**28
  call calc(n)
  n=2**30
  call calc(n)
contains
  subroutine calc(n)
    integer, intent(in) :: n
    double precision, parameter  :: a=0.0, b=1.0
    double precision :: pi, t1, t2, x, h, integral=0.0
    integer :: i
    t1 = omp_get_wtime()
    integral = ( ( 4.0 / ( 1.0 + a * a ) ) +  &
                 ( 4.0 / ( 1.0 + b * b ) ) ) / 2.0
    x = a
    h = ( b - a ) / n
    do i = 1, n - 1
      x = a + h * i
      integral = integral + 4.0 / (1.0 + x * x)
    end do
    pi = integral * h
    t2 = omp_get_wtime()
    print*, "Partitions:", n
    print*, "Result:", pi, "    Error:", dacos(-1.d0) - pi
    print*, "Elapsed time:", t2 - t1
    print*, ""
  end subroutine
end program list06s
```

RESULTADO

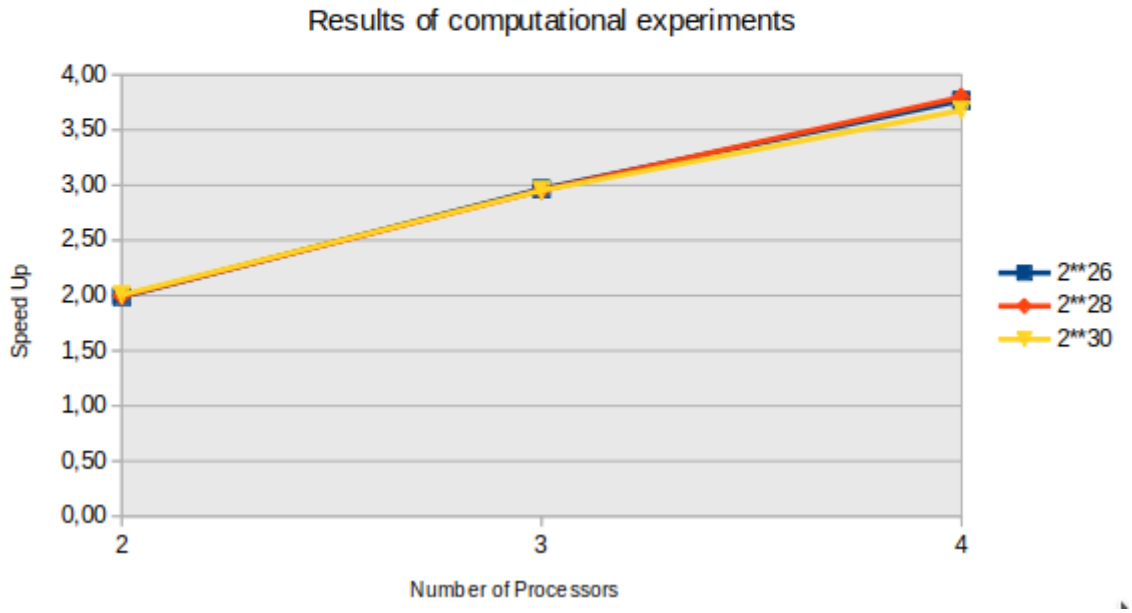
```
$ gfortran -fopenmp -o list06s list06s.f90
$ ./list06s
 Partitions:    67108864
 Result:   3.1415926535890550          Error:   7.3807626677080407E-013
 Elapsed time:  0.85066184799870825

 Partitions:   268435456
 Result:   3.1415926535898735          Error:  -8.0380146982861334E-014
 Elapsed time:   3.3845648820024508

 Partitions:  1073741824
 Result:   3.1415926535901244          Error:  -3.3129055054814671E-013
 Elapsed time:   13.583390687999781
```

SPEED UP

Partitions	Serial Algorithm	2			3			4		
		Time	Speed Up	Efficiency	Time	Speed Up	Efficiency	Time	Speed Up	Efficiency
2**26	0,8506618	4,28E-01	1,99	0,99	0,2868116	2,97	0,99	0,2257795	3,77	0,94
2**28	3,3845649	1,6969807	1,99	1,00	1,1460635	2,95	0,98	0,8909184	3,80	0,95
2**30	13,583391	6,7740605	2,01	1,00	4,6008847	2,95	0,98	3,6927662	3,68	0,92



CAT /PROC/CPUINFO (processador de 2 núcleos)

```
$ cat /proc/cpuinfo
processor       : 0
vendor_id       : GenuineIntel
cpu family      : 6
model           : 142
model name      : Intel(R) Core(TM) i7-7500U CPU @ 2.70GHz
stepping        : 9
microcode       : 0xb4
cpu MHz         : 600.047
cache size      : 4096 KB
physical id     : 0
siblings        : 4
core id         : 0
cpu cores       : 2
apicid          : 0
initial apicid  : 0
fpu             : yes
fpu_exception   : yes
cpuid level     : 22
wp              : yes
flags           : fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush dts
acpi mmx fxsr sse sse2 ss ht tm pbe syscall nx pdpe1gb rdtscp lm constant_tsc art arch_perfmon pebs bts
rep_good nopl xtopology nonstop_tsc cpuid aperfmperf tsc_known_freq pni pclmulqdq dtes64 monitor ds_cpl
vmx est tm2 ssse3 sdbg fma cx16 xtpr pdcm pcid sse4_1 sse4_2 x2apic movbe popcnt tsc_deadline_timer aes
xsave avx f16c rdrand lahf_lm abm 3dnowprefetch cpuid_fault epb invpcid_single pti ssbd ibrs ibpb stibp
tpr_shadow vnmi flexpriority ept vpid ept_ad fsgsbase tsc_adjust bmi1 avx2 smep bmi2 erms invpcid mpx
rdseed adx smap clflushopt intel_pt xsaveopt xsavec xgetbv1 xsaves dtherm ida arat pln pts hwp
hwp_notify hwp_act_window hwp_epp md_clear flush_l1d
bugs            : cpu_meltdown spectre_v1 spectre_v2 spec_store_bypass l1tf mds swapgs
bogomips        : 5808.00
clflush size    : 64
cache_alignment : 64
address sizes   : 39 bits physical, 48 bits virtual
power management:
```

RODANDO EM UM PROCESSADOR DE 4 NÚCLEOS

```
ef@TOPS:~$ cat /proc/cpuinfo
processor       : 0
vendor_id       : GenuineIntel
cpu family      : 6
model           : 42
model name      : Intel(R) Core(TM) i7-2630QM CPU @ 2.00GHz
stepping        : 7
microcode       : 0x2f
cpu MHz         : 798.191
cache size      : 6144 KB
physical id     : 0
siblings        : 8
core id         : 0
cpu cores       : 4
apicid          : 0
initial apicid  : 0
fpu             : yes
fpu_exception   : yes
cpuid level     : 13
wp              : yes
flags           : fpu vme de pse tsc msr pae mce cx8 apic sep mtrr pge mca cmov pat pse36 clflush dts
acpi mmx fxsr sse sse2 ss ht tm pbe syscall nx rdtscp lm constant_tsc arch_perfmon pebs bts nopl
xtopology nonstop_tsc cpuid aperfmperf pni pclmulqdq dtes64 monitor ds_cpl vmx est tm2 ssse3 cx16 xtpr
pdcm pcid sse4_1 sse4_2 x2apic popcnt tsc_deadline_timer aes xsave avx lahf_lm epb pti ssbd ibrs ibpb
stibp tpr_shadow vnmi flexpriority ept vpid xsaveopt dtherm ida arat pln pts md_clear flush_l1d
bugs            : cpu_meltdown spectre_v1 spectre_v2 spec_store_bypass l1tf mds swapgs
bogomips        : 3990.95
clflush size    : 64
cache_alignment : 64
address sizes   : 36 bits physical, 48 bits virtual
power management:
```

PARALELO

```
ef@TOPS:~$ gfortran -fopenmp list06p.f90
ef@TOPS:~$ ./a.out
 Partitions:    67108864     Threads:           2
 Result:   3.1415926535892620          Error:   5.3113069498067489E-013
 Elapsed time:  0.63812972799996714

 Partitions:    67108864     Threads:           4
 Result:   3.1415926535894432          Error:   3.4994229736184934E-013
 Elapsed time:  0.34222608099997842

 Partitions:    67108864     Threads:           8
 Result:   3.1415926535898167          Error:  -2.3536728122053319E-014
 Elapsed time:  0.17422291200000473

 Partitions:   268435456     Threads:           2
 Result:   3.1415926535900667          Error:  -2.7355895326763857E-013
 Elapsed time:   2.5080567939999696

 Partitions:   268435456     Threads:           4
 Result:   3.1415926535901377          Error:  -3.4461322684364859E-013
 Elapsed time:   1.3487727319999863

 Partitions:   268435456     Threads:           8
 Result:   3.1415926535898744          Error:  -8.1268325402561459E-014
 Elapsed time:  0.71615645599996469

 Partitions:  1073741824     Threads:           2
 Result:   3.1415926535899747          Error:  -1.8163248682867561E-013
 Elapsed time:   10.058801081000013

 Partitions:  1073741824     Threads:           4
 Result:   3.1415926535898269          Error:  -3.3750779948604759E-014
 Elapsed time:   5.3947735290000196

 Partitions:  1073741824     Threads:           8
 Result:   3.1415926535897096          Error:   8.3488771451811772E-014
 Elapsed time:   2.8449099649999994
```

SÉRIE

```
ef@TOPS:~$ gfortran -fopenmp list06s.f90
ef@TOPS:~$ ./a.out
 Partitions:    67108864
 Result:   3.1415926535890550          Error:   7.3807626677080407E-013
 Elapsed time:   1.2188644640000348

 Partitions:   268435456
 Result:   3.1415926535898735          Error:  -8.0380146982861334E-014
 Elapsed time:   4.8607448090000389

 Partitions:  1073741824
 Result:   3.1415926535901244          Error:  -3.3129055054814671E-013
 Elapsed time:   19.422818975000041
```

SPEED UP

Partitions	Serial Algorithm	2			4			8		
		Time	Speed Up	Efficiency	Time	Speed Up	Efficiency	Time	Speed Up	Efficiency
2**26	1,2188645	6,38E-01	1,91	0,96	0,3422261	3,56	0,89	0,1742229	7,00	0,87
2**28	4,8607448	2,5080568	1,94	0,97	1,3487727	3,60	0,90	0,7161565	6,79	0,85
2**30	19,422819	10,058801	1,93	0,97	5,3947735	3,60	0,90	2,84491	6,83	0,85