PERF016 – Parallel performances d'INFO_MODE/ MACRO_MODE_MECA

Abstract:

The purpose of this benchmark is to measure the performances of the office plurality of two strategies of parallelization in INFO_MODE and MACRO_MODE_MECA. The savings of time and memory are interesting and these accelerations (up to 2 times in peak report, 30/40 times in time on about sixty processors) can really facilitate many dynamic studies on modal base.

1 Problem of reference

the perf013c benchmark is used as problem of reference.

Large modal computations, in the face of problem and/or of many searched modes, are carried out *via* operator MACRO_MODE_MECA. This operator cuts out the frequential tape of search in several contiguous sub-bands so as to reduce consumption in time and memory of computation. This search by sub-bands also makes it possible to improve the robustness and the accuracy of the results.
To limit the déséquilibrages of load in modal computation, one pre-gauges them *via* a call to INFO_MODE. This last operator activates same the two levels of parallelism as those of MACRO_MODE_MECA.

Decomposition in sub-bands gets finally a last advantage, it arranges level of an explicit and very effective parallelism, by allowing the distribution of each sub-band on 1 or several processors. Thus, the modal computations operated within each sub-band proceed jointly. If several processors are available for each sub-band, one can even call a second level of parallelism *via* the direct linear solver MUMPS. These two combined levels of parallelism make it possible to gain much in time and a little in peak report RAM (key word NIVEAU_PARALLELISME=' COMPLET', value by default).

To center the gains mainly on the peak report or because the number of processors available is insufficient compared to the number of sub-bands, one can also limit parallelism to the only second level, that of MUMPS (NIVEAU_PARALLELISME=' PARTIEL').

The purpose of this benchmark is to measure the performances of these two strategies of parallelization in INFO_MODE and MACRO_MODE_MECA. The savings of time and memory are interesting and these accelerations (up to 2 times in peak report, 30/40 times in time on about sixty processors) can really facilitate many dynamic studies on modal base.

The computation modal used takes again the modelization C perf013 *benchmark*: square plate with a grid in shell elements ($N=4\mathrm{M}$ degrees of freedom), linear finite elements, search for 50 eigen modes in 4 sub-bands with the modal solver by default and the linear solver MUMPS. One tests the sequential configuration (modelization A), as well as the two parallel strategies out of 4 and 16 processors (modelizations B/C and D/E).

For computations MACRO_MODE_MECA , one checks various values of frequency and different component from the unit effective modal masses [1] .
For computations INFO_MODE, one tests the minimal, maximum values and sum of the components "NB_MODE" of the generated array.

2 Reference solution

See the perf013c benchmark.

1 At the boundaries of the sub-bands to detect possible problems in communications MPI

3 Modelization A

3.1 Characteristic of the modelization A

Number of processor: 1

One uses the modelization C perf0013 benchmark: square plate with a grid in shell elements, linear finite elements, search for 50 eigen modes *via* operator MACRO_MODE_MECA. One uses the modal solver and the value of the test of Sturm type by default.
One pre-gauges modal computation by a call to INFO_MODE on the sub-bands of frequencies: $[0.1\text{GHz}, 1.1\,GHz]$, $[1.1\text{GHz}, 2.0\,Hz]$, $[2.0\text{GHz}, 3.0\,GHz]$ and $[3.0\text{GHz}, 4.0\,GHz]$.

One parameter the brick linear solver with the best currently available tools in *Code_Aster* for this kind of computation: the MUMPS solver (METHODE=' MUMPS') coupled with renumerotor QAMD (RENUM=' QAMD') and called in memory (to accelerate the many descent-increase, GESTION_MEMOIRE=' IN_CORE').

Characteristics of mesh: 667.489 NOEUD, 3.264 SEG2 and 665.856 QUAD4.
Many degrees of freedom : 4.024.530.

3.2 Results

Quantity	Reference
FREQ n°1	47.605
MASS_EFFE_UN_DZ n°1	0.420180
FREQ n°10	1546.457
MASS_EFFE_UN_DZ n°10	3.423 10-3
FREQ n°21	3978.453
MASS_EFFE_UN_DZ n°21	1.467 10-3

4 Modelization B

4.1 Characteristic of the modelization B

Many processors: 4.

Identical to the modelization A but computation is carried out here on 4 processors by privileging the first level of parallelism (that by default *via* NIVEAU_PARALLELISME=' COMPLET').
Each sub-band is entrusted to a processor. The occurrences MUMPS, called jointly by each sub-band, thus work only on 1 processor.

4.2 Results

Identical to modelization A.

5 Modélisation C

5.1 Characteristic of the modelization C

Many processors: 16.

Identical to the modelization A but computation is carried out here on 16 processors by means of two levels of parallelism (operation by default *via* NIVEAU_PARALLELISME=' COMPLET').
Each sub-band is entrusted to four processors. The occurrences MUMPS, called jointly by each sub-band, thus work each one on 4 processors.

5.2 Results

Identical to modelization A.

6 Modélisation D

6.1 Characteristic of the modelization D

Number of processor: 4.

Identical to the modelization A but computation is carried out here on 4 processors by privileging the second level of parallelism (NIVEAU_PARALLELISME=' PARTIEL'). All the sub-bands are treated the ones after the others.

Only the occurrences MUMPS, called for numerical factorizations and the descent-increase required by the modal solver, work in parallel on 4 processors.

6.2 Results

Identical to modelization A.

7 Modélisation E

7.1 Characteristic of the modelization E

Identical to the modelization D but computation is carried out here on 16 processors.

7.2 Results

Identical to modelization A.

8 Synthèse of the results

These results were got in version 11.3.9 on machine IVANOE with 1 process MPI by node. For recall, the performances in version 11.2 (parameters by default) were: $9296\,s$ and $23.5\,Go$ (for MACRO_MODE_MECA) and $2016\,s$ and $17.0\,Go$ (for INFO_MODE).

V11.3.9 INFO_MODE/ MACRO_MODE_MECA	**A**	**B**	**C**	**D**	**E**
Standard of parallelism	1×1	4×1	4×4	1×4	1×16
Elapsed Time	$1008\,s$ $3544\,s$	$387\,s$ $1123\,s$	$170\,s$ $636\,s$	$422\,s$ $1853\,s$	$253\,s$ $1432\,s$
Vmpeak	$7.8\,Go$ $17.2\,Go$	$7.8\,Go$ $19.5\,Go$	$7.8\,Go$ $13.8\,Go$	$7.8\,Go$ $10.6\,Go$	$7.8\,Go$ $9.5\,Go$