PERF014 – Contact between two plates in parallel

Summary:

The objective of this CAS-test is to measure the parallel performances of a calculation with a large number of degrees of freedom of contact. It consists of two plates making contact with a rigid foundation.

This case test is declined in 3 quasi-identical modelings. The differences are related to the smoothness of the grids used like with the number of processors:

1) Modeling a: 8900 elements out of 1 processor,
2) Modeling b: 40000 elements out of 4 processors,
3) Modeling C: 63000 elements out of 8 processors.
1 Problem of reference

1.1 Geometry

The geometry of the problem of contact is the following one:

1.2 Properties of material

• $E = 2.1 \times 10^5$ MPa
• $\nu = 0.3$

1.3 Boundary conditions and loadings

Imposed displacement:

- Side faces : $DX = DY = DZ = 0$.
- Foundation : $DX = DY = DZ = 0$.

Pressure imposed on the higher face:

$P = 100$ MPa
2 Reference solution

2.1 Method of calculating

The results of reference are of standard not-regression.

2.2 Sizes and results of reference

Resultant of the efforts according to $DZ$ with embedding.

Maximum displacement on the enforcement zone of the effort of pressure.

2.3 Uncertainties on the solution

Solution of not-regression.
3 Modeling A

3.1 Characteristics of modeling

Modeling is 3D, the formulation of the contact is CONTINUOUS (without friction). The non-linear solver is NEWTON_KRYLOV associated to the iterative linear solver PETSC.

3.2 Characteristics of the grid

Many nodes 14,011
Many meshes 19,665
That is to say:

<table>
<thead>
<tr>
<th>Element Type</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEG2</td>
<td>940</td>
</tr>
<tr>
<td>QUAD4</td>
<td>9,821</td>
</tr>
<tr>
<td>HEXA8</td>
<td>8,904</td>
</tr>
</tbody>
</table>

3.3 Sizes tested and results

Not-regression.

3.4 Environment of execution

Many processors: 1

<table>
<thead>
<tr>
<th>Machine</th>
<th>Version</th>
<th>Memory (Mo)</th>
<th>Many degrees of freedom</th>
<th>Time execution (STAT_NON_LINE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Allocated</td>
<td>Used</td>
<td>TO USE</td>
</tr>
<tr>
<td>Aster4</td>
<td>11.3.4</td>
<td>512</td>
<td>620</td>
<td>46,325</td>
</tr>
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</table>

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4 Modeling B

4.1 Characteristics of modeling

Modeling is 3D, the formulation of the contact is CONTINUOUS (without friction). The non-linear solver is NEWTON_KRYLOV associated to the iterative linear solver PETSC.

4.2 Characteristics of the grid

Many nodes 61,510
Many meshes 84,225
That is to say:
SEG2 2,124
QUAD4 42,101
HEXA8 40,000

4.3 Sizes tested and results

Not-regression.

4.4 Environment of execution

Many processors: 4

<table>
<thead>
<tr>
<th>Machine</th>
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<th>Memory (Mo)</th>
<th>Number DDL</th>
<th>Time execution (STAT_NON_LINE)</th>
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<td></td>
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<td>Used</td>
<td>TO USE</td>
</tr>
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<td>1320</td>
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</table>

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5  Modeling C

5.1  Characteristics of modeling

Modeling is 3D, the formulation of the contact is CONTINUOUS (without friction). The non-linear solver is NEWTON_KRYLOV associated to the iterative linear solver PETSC.

5.2  Characteristics of the grid

5.3  Sizes tested and results

Not-regression.

5.4  Environment of execution

Many processors: 8

<table>
<thead>
<tr>
<th>Machine</th>
<th>Version</th>
<th>Memory (Mo)</th>
<th>Many degrees of freedom</th>
<th>Time execution (STAT_NON_LINE) (dryness)</th>
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</thead>
<tbody>
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<td></td>
<td>Allocated</td>
<td>Used</td>
<td>TO USE</td>
</tr>
<tr>
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6 Summary of the results

This benchmark implements a calculation of contact of which the number of potential nodes of contact is approximately 10 % amongst degrees of freedom total. That represents a significant portion compared to what one usually meets in the studies in mechanics of the structures. One shows through 3 modelings the interest of parallel calculation for this kind of problem. Parallelism is made possible for two reasons:

- on the one hand thanks to the elementary approach of the formulation CONTINUOUS and distribution of resulting calculations,
- in addition thanks to the non-linear solvor NEWTON_KRYLOV coupled to a robust parallel iterative solvor.