Nastran 2021.1
What’s New
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SOL 101 Linear Statics

SPARSESOLVER DCMP(FACTMETH=MUMPS)

Matrix Size = 50200099
Number of Nonzeros = 1037411735
Number of Loads = 4
Distributed Memory Parallelism = 2
Shared Memory Parallelism = 16
Required Memory = 189349 MB

MUMPs

MUltifrontal Massively Parallel Sparse direct Solver

Model Credited to FEA Academy
SOL 101 Linear Statics

SPARSE SOLVER DCMP (FACTMETH=MUMPS)

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MUMPs
MULTifrontal Massively Parallel Sparse direct Solver

Model Credited to FEA Academy
Introduction

- Increasing problem sizes ranging in the 100’s of Millions of Degrees of Freedom (DOF) puts performance demands on MSC Nastran solvers.

- MSC Nastran introduced support for Linear Statics (SOL 101) using the MUMPs solver (MUltifrontal Massively Parallel Sparse direct Solver) in 2021.

- Further performance tuning has been underway, given that the solution of linear equations comprise more than 60% of the elapsed time in SOL 101 with most of the time consumed in the pre-processing phase.

Benefits

Various techniques including compression have resulted in

- Strong scaling and scale out capability across multiple machines/hosts.
- Solver performance improvement : 20-60% faster with strong scalability.
- Overall performance improvement : 15-40% faster with strong scalability.
- Reduced solver memory requirement : 2-10% approx.
- Significantly faster than MKL Pardiso : 30-60% with strong scalability.
- Lesser memory required per machine/host via DMP compared to MKL Pardiso.
- SOL 101 linear contact is supported. Inertia relief -1, -2 is supported.
Example 1: Performance Results for SOL 101

- Number of D.O.F: 50M D.O.F
- 2D elements: 8,184,539
- No of load cases: 4

*The test cases were executed on a Linux machine with Intel(R) Xeon(R) Gold 6226R CPU @ 2.90GHz, with 1.2TB of Memory.
Example 2 : Performance Results for SOL 101 with Inertia relief

- Number of D.O.F : 24M D.O.F.
- 3D elements : 5,069,073
- No of load cases : 3

*The test cases were executed on a Linux machine with Intel(R) Xeon(R) Gold 6226R CPU @ 2.90GHz, with 1.2TB of Memory.*
Two Examples of MUMPs relative to Pardiso solver for SOL 101

*The test cases were executed on a Linux machine with Intel(R) Xeon(R) Gold 6226R CPU @ 2.90GHz, with 1.2TB of Memory.
Conclusion

- Overall strong scalability achieved: 20-60% faster.
- Models with dominant shell elements showed higher benefit.
- Yes.. absolutely nothing needed from the user to leverage this!

Limitations

- Similar performance on MUMPs DMP configuration, slower due to communication overhead between compute nodes and highly depends on the network interconnect.
Technical Discussion

INPUTS:
• Invoke MUMPS Solver by using the SPARSESOLVER executive control statement.
• Use DCMP module of SPARSESOLVER statement for sol 101.
• Use NLSOLV module of SPARSESOLVER statement for sol 101 linear contact.

SOL 101
SPARSESOLVER DCMP(FACTMETH=mumps) CEND

OUTPUTS IN F04:

<table>
<thead>
<tr>
<th>12:38:50</th>
<th>11:27</th>
<th>56728.0</th>
<th>29.0</th>
<th>690.8</th>
<th>20.4</th>
<th>MUMPS</th>
<th>BGN</th>
</tr>
</thead>
</table>

- MATRIX SIZE = 50200099
- NUMBER OF NONZEROS = 1037411735
- NUMBER OF LOADS = 4
  - DMP = 2
  - SHP = 16
- AVAILABLE MEMORY = 280264 MB
- REQUIRED INCORE MEMORY = 189349 MB
Fatigue

CAEfatigue Integration with MSC Nastran
Fatigue

CAEfatigue Integration with MSC Nastran
CAEfatigue integration with MSC Nastran

MSC Nastran 2021.1
- Processes Stresses from MSC Nastran
- Support for time based solver (stress and strain)
- Support for time based solver (spot welds)
- Tuned for performance and scalability of linear statics (SOL 101), normal modes (SOL 103), and transient analysis (SOL 112)

MSC Nastran 2021.2
- CAEFatigue as default fatigue solver for time domain Nastran NEF

Future
- CAEFatigue as default fatigue solver for frequency domain Nastran NEF
The CAEfatigue solver is now integrated into standard Stress-Life (SN) and Strain-Life (eN) including fatigue analysis of spot welds.

Performance gain is most notable for large models subject to complicated duty cycle loading with multiple events.
CAEFatigue Integration and Performance

The Fatigue solver has been tuned for performance and scalability of
- linear statics (SOL 101)
- normal modes (SOL 103)
- transient analysis (SOL 112)

Truck Model
- 580,758 DOFs
- 96,793 Grids
- 91,524 Shell Elements
- 12 Load locations
- 10 Loading Events
- ~20,000 time points per event per location
SOL 101/103/112/108/111
CEND
FATIGUE = 42 \rightarrow output request
BEGIN BULK
FTGDEF 42 ... \rightarrow define where on model
FTGPARM 42 ... \rightarrow define what (SN, eN, etc.)
FTGSEQ 42 ... \rightarrow define cyclic loading
MATFTG \leftarrow define material properties...
END BULK

CAEFatigue in MSC Nastran Card

Pseudo Damage in CAEFatigue application
CAEFatigue new “Hot Spot” calculation

“Hot Spot” (critical location detection) capability

- Substantially reduce compute time
- Significantly reduce output
- But still identify critical locations accurately
  - NHS = # of hot spots to identify
  - HSGATE = # of element layers around each hot spot to retain

Find Failure Points Quickly

<table>
<thead>
<tr>
<th>FTGDEF</th>
<th>ID</th>
<th>TOPSTR</th>
<th>PFTGID</th>
<th>TOPDMG</th>
<th>NENTS</th>
<th>maxENTS</th>
<th>NHS</th>
<th>HSGATE</th>
</tr>
</thead>
</table>

hexagonmi.com | mscsoftware.com
Contact Modeling

Accelerated Separation Check for Node to Segment Contact
Contact Modeling

Accelerated Separation Check for Node to Segment Contact
Performance Improvements for MSC Nastran nonlinear contact SOL 400

SEPACC = 1

Accelerated Separation Check
- Off: 1742
- On: 1036
<table>
<thead>
<tr>
<th>SEPACC</th>
<th>Max Contact force</th>
<th>Iteration #</th>
<th>Separation #</th>
<th>Wall Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (off)</td>
<td>4.32E+01</td>
<td>394</td>
<td>92</td>
<td>2,729</td>
</tr>
<tr>
<td>1 (on )</td>
<td>4.32E+01</td>
<td>347</td>
<td>194</td>
<td>2,373</td>
</tr>
</tbody>
</table>
scPost can be used for some MSC Nastran post-processing
Vibration of Heavy Fluids
Frequency Response Analysis

Coupled Modes Enhancement for Heavy Fluid-Structure interaction
Vibration of Heavy Fluids
Frequency Response Analysis

Coupled Modes Enhancement for Heavy Fluid-Structure interaction
Real Coupled Modes Support for

Real Normal Modes SOL 103

Modal Frequency Response 111

Modal Transient Response 112
Compute 50 coupled modes:

- STRUCTURE DOF: 189,852
- FLUID DOF: 394,887
- TOTAL: 600K
Compute 50 coupled modes:

- Complex Modes SOL 107
- Real Modes SOL 103

Serial (SMP=0)
Compute 50 coupled modes:

Real Modes
SOL 103

Complex Modes
SOL 107

Mode #7
Compute 50 coupled modes:

- Serial (SMP=0)
- SMP = 2
- SMP = 4

Time in Seconds

Real Modes SOL 103
Real Coupled Modes Support for External Acoustic Problems in Modal Frequency Response

Design Studies
- Speed
  - Modal Frequency Response
    SOL 111 with Weak Coupling
    ACOWEAK = Yes
- Modal Frequency Response
  SOL 111 with Strong Coupling
  ACOWEAK = No

Validation
- Accuracy
  - Direct Frequency Response
    SOL 108
Example of Air-Solid-Fluid Coupling

Accuracy and performance comparison of External acoustic ACOWEAK option with the Real Coupled Modes

Number of D.O.F : 128K D.O.F
SOL 111 ACOWEAK=NO and YES both use 200 real normal modes
100 frequency response computation

The test cases were executed on a Linux machine with Intel(R) Xeon(R) Gold 6226R CPU @ 2.90GHz, with 1.2TB of Memory.
Thank You

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