Simultaneous Calculation with ANSYS

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WOST 2014, Weimar, Nov. 7th
Content

• General Usage
• Workbench Design Point Handling
• Cluster Strategy: “Fujitsu –RDO-Cluster”
• Example and Performance
General Usage & Licensing
Which Parameters can be chosen?

- Geometry parameters (CAD, DesignModeler, …)
- Engineering data parameters (Young’s modulus, density, …)
- Mesh parameters (element size, …)
- Boundary condition parameters (pressure load magnitude, …)
- APDL, Excel, …

→ All parameters which are listed in the Parameter Manager
• One base license can be multiplied by ANSYS HPC Parametric Packs
The following table lists ANSYS products that are amplified by the ANSYS HPC Parametric Pack license.

| ANSYS CFD, ANSYS CFD Solver          |
| ANSYS CFD PrepPost                  |
| ANSYS CFD-Post                      |
| ANSYS CFX, ANSYS CFX Solver         |
| ANSYS Fluent, ANSYS Fluent Solver   |
| ANSYS Fluent PEM Fuel Cell Module, ANSYS Fluent SOFC Fuel Cell Module |
| ANSYS Professional (at R15.0)       |
| ANSYS Structural, ANSYS Structural Solver (at R15.0) |
| ANSYS Mechanical                   |
| ANSYS Mechanical Solver (at R15.0)  |
| ANSYS Mechanical EMAG              |
| ANSYS Mechanical CFD-Flo           |
| ANSYS Multiphysics                 |
| ANSYS Multiphysics Solver (at R15.0) |
| ANSYS Fatigue Module               |
| ANSYS HPC                          |
| ANSYS HPC Pack                     |
| ANSYS HPC Workgroup, ANSYS HPC Enterprise |
| ANSYS Meshing                      |
| ANSYS Extended Meshing (incl. TGrid, ANSYS ICEM CFD functionality) |
| ANSYS TurboGrid                    |
| ANSYS Polyflow, ANSYS Polyflow Solver |
| ANSYS Polyflow BlowMolding, ANSYS Polyflow Extrusion |
Multiplying licenses enables you to drastically reduce time to innovation → Simultaneous Processing
Setup 1: All Processes Local
- Geometry Update
- Meshing Process
- Boundary Conditions Mapping
- Solution Process
- Result Extraction
- Result Processing

Setup 2: Local Pre/Post and Remote Solve Process
- Geometry Update
- Meshing Process
- Boundary Conditions Mapping
- Result Extraction
- Result Processing
- Solution Process

Setup 3: Main Processes Remote
- Geometry Update
- Meshing Process
- Boundary Conditions Mapping
- Solution Process
- Result Extraction
- Result Processing
Simulation ist mehr als Software®

Workbench DP Handling
### Setup 1: All Processes Local

<table>
<thead>
<tr>
<th>Local (e.g. workstation)</th>
<th>Remote (e.g. calculation node)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry Update</td>
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</tbody>
</table>
Setup 1: All Processes Local

- All design points are calculated sequentially which means step by step (NO simultaneous processes)

Solution Process:
- Update Option: Use application default → Local

Design Point Update Process:
- Update Option: Run in Foreground → Local
Setup 2: Local Pre/Post and Remote Solve Process

Local (e.g. workstation)  Remote (e.g. calculation node)

- Geometry Update
- Meshing Process
- Boundary Conditions Mapping

Input File

Solution Process

Results as rst-file (large)

Result Extraction

Result Processing
• All design points are calculated sequentially or simultaneously
• Licensing:
  • On Demand
    • **Base licenses** is used → sequential process of design points
    • **NO ANSYS HPC Parametric Pack** available
  • **Reserved**
    • **Base licenses** useable
      • If multiple base licenses available → simultaneous process possible
    • **ANSYS HPC Parametric Pack** useable → simultaneous process possible
    • **NO** usage of “ANSWAIT”-variable allowed
Setup 2: Local Pre/Post and Remote Solve Process

- Licensing: On Demand → Sequential process of design points

- Solution Process:
  - Update Option: Submit to Remote Solve Manager → Compute Server

- Design Point Update Process:
  - Update Option: Run in Foreground → Local
Setup 2: Local Pre/Post and Remote Solve Process

- Licensing: Reserved Licenses → Simultaneous process of design points possible (ANSYS HPC Parametric Pack usage)

- Solution Process:
  - Update Option: Submit to Remote Solve Manager → Compute Server
  - Design Point Update Process:
  - Update Option: Run in Foreground → Local
Setup 3: Main Processes Remote = highest performance

Local (e.g. workstation) → Remote (e.g. calculation node)

- Geometry Update
- Archive File .wbpz
- Extracted Results as table (small)
- Result Processing
- Meshing Process
- Boundary Conditions Mapping
- Solution Process
- Result Extraction

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All design points are calculated sequentially or simultaneously

Solution Process:
- Update Option: Use application default → local run on Compute Server
- Design Point Update Process:
  - Update Option: Submit to Remote Solve Manager → Compute Server
  - Processing order defined by 3 types of settings (see following slides)
Setup 3.1: One Job for All Design Points

- Sequential process for all design points which means step by step, not simultaneously
- 1 Job is sent to RSM including dp1, dp2, … dpn
Setup 3.2: One Job Each Design Point

- Number of jobs is equal to design points
  - e.g. 32 design points → 32 jobs
  - Jobs can be processed sequentially or simultaneously, depending on licensing and **adjusted** RSM settings
• Maximum number of jobs is limited
  • Jobs can be processed sequentially or simultaneously, depending on licensing and static RSM setting
  • All Design Points in the Parameter Manager are equally distributed to the defined number of jobs
License Tracking for „Reserved Licenses“

- License tracking requires a solution started from solution cell in project manager (with Mechanical closed)
- There are two locations, where used licenses are displayed
  - In cells of the system in project manager
  - In the Parameter Set / Reserved License Set setting
In case of processes terminated abnormally, reserved licenses remain reserved and will not be available.

However, these licenses can be released manually.
Restrictions in Multiplying Licenses

- One HPC Parametric Pack amplifies only one base license

- A mixture of amplified and non amplified base licenses is not possible
  - E. g.
    - 3 x ANSYS Mechanical + 1 x ANSYS HPC Parametric Pack available
    - For one parametric study, you may use EITHER
      - 1 x ANSYS Mechanical + 1 x ANSYS HPC Parametric Pack for 4 simultaneous jobs
    - OR
      - 3 x ANSYS Mechanical for 3 simultaneous jobs
    - BUT NOT
      - 1 x ANSYS Mechanical + 1 x ANSYS HPC Parametric Pack + 2 x ANSYS Mechanical for 6 simultaneous jobs
Parallel Execution Mode for Multicore Processing

- Switch default setting “Serial” (1 Core) to “Parallel” (Multicore)

- Example:
  - 8 core machine
  - Setup for simultaneous processing enabled (Reserved Licenses + ANSYS HPC Parametric Pack + ANSYS Mechanical, RSM Limiter: 50 Jobs)
  - Specified Maximum Number of Jobs: 4
  - Maximum Number of Processes per Job: 2 (means 2 Cores per Job)
  → 8 cores in use while processing
Calculation Modes – SMP and DMP

Setting in „Component Execution Mode“

• Serial: SMP single core calculation
  → Shared Memory ANSYS

• Parallel:
  • Default calculation mode: DMP multicore calculation with n cores
    → Distributed ANSYS
  • If DMP cannot be used for calculation, in most cases the mode changes automatically to SMP.
  • Manual change of calculation mode to SMP possible
Design Point Update Order

• Update from Current: (recommended!)
  • Each design point is updated from the initial model (current design point in the design point manager)

• Update Design Points in Order:
  • Next design point refers to the previous design point which was updated

• Pro
  • If changes from DP to DP are small → time saving

• Con
  • If one DP update is failed → next DP will fail
Geometry Update with Pre-RSM Foreground Update

- In case of simultaneous settings, an upfront update of all Geometries is done automatically, no matter which Pre-RSM option is set.

- In the other cases, the user can choose.
Application Default Setting in Update Option

• The update option in the solution cell has to be set to „Eigener Computer“. Otherwise a warning arises. The default solve setting need to be defined in the Solve Process Setting in the Mechanical Editor.
Update Parameters vs. Update full Project

• Update Parameters: Only unsolved analysis systems with parameters will be updated
• Update full Project: All unsolved analysis systems will be updated
Example

• Simultaneous Processing with ANSYS HPC Parametric Pack
  • 32 core remote compute server machine
  • 1 x ANSYS HPC Parametric Pack
  • 1 x ANSYS HPC Pack
  • 1 x ANSYS Mechanical
  • 100 design points
  • Geometry parameters + load parameters
Example

- Simultaneous Processing with ANSYS HPC Parametric Pack
Example

- Simultaneous Processing with ANSYS HPC Parametric Pack

Recommended Setup
Example - Summary

- Simultaneous Processing with ANSYS HPC Parametric Pack
  - Simultaneous processing enabled by
    - “Reserved Licenses”
    - Specified Maximum Number of Jobs: 4
    - ANSYS HPC Parametric Pack
  - All geometries are updated locally upfront
  - 4 jobs in process (each job includes 25 design points), 0 jobs in RSM-Queue
  - 8 cores per job $\rightarrow$ 32 cores in process; enabled by ANSYS HPC Pack
  - Specified Maximum Number of Jobs $<$ RSM Limiter
• “ANSWAIT“ variable must not be set
• Set user specific variable:
  • ANSYS_FRAMEWORK_ENABLE_REDUCE_RSM_FILE_TRANSFER=1
  • Reduces transfer from compute server to local client to scalar results in parameter manager only
• BUT: From client TO compute server, the full project incl. all included data is transferred
  → Recommendation: clear all simulation results from the current design in the Mechanical Editor
• For selecting licenses in „reserved licenses“, they need to be activated in “Licenses Preferences” (e. g. Mechanical = 1)
Job Limitation
RSM Limiter – Limiting Maximum Number of Jobs

- RSM Settings for Compute Server
  - RSM limits Maximum Number of Jobs → RSM Limiter
Job Limitation – 3 Ways to Adjust

- RSM Limiter
- optiSLang
- Parameter Set

Job1, Job2, Job3, Job4, Job5, Job6, Job7, Job8
Job Limitation – Adjustment for Setup 2

RSM Limiter

optiSLang

Parameter Set

Job1, Job2, Job3, Job4, Job5, Job6, Job7, Job8
Job Limitation – Adjustment for Setup 3

- Job1
- Job2
- Job3
- Job4
- Job5
- Job6
- Job7
- Job8

RSM Limiter

optiSLang

Parameter Set
Cloud Computing

Fujitsu RDO cluster
Optimisation Cluster elements

Head node = 1x PRIMERGY RX350 S8

- CPU: E5-2637 v2 @ 3.50GHz (4 core)
- MEM: 8*16384 MB /DDR3 /1866 Mhz
- 1*NVIDIA Tesla K40m
- Mellanox FDR 1 port
- 4 * SAS 900GB 10 k
  - 2 disc in RAID1 for RedHat and HCS
  - 2 disc in RAID0 for data

Compute nodes = 8x PRIMERGY CX250 S2

- CPU: 2*E5-2697V2 (12 core, 2.7GHz)
- MEM: 16*8GB /1866 Mhz (on cn1 and cn2 8*16GB)
- Mellanox FDR 1 port
- RAID controller 0/1
- 2 * SAS 900GB 10 k
  - 2 disc in RAID0 for RedHat & data

System stack = Fujitsu HPC Cluster Suite (HCS)

- OS: RedHat Enterprise Linux 6.4
- HCS version 2.2_04
  - Advanced Edition
- PBSpro: 12.2.0.133411
- ICR certified

Fast interconnect = InfiniBand

- Mellanox FDR for MPI and I/O
- GbE for management and control
RDO Cluster Setup

**Head node**
RX350
8 cores

**Compute nodes**
CX250
8 cores used per job

- ANSYS RSM
- PBS accessing Compute Nodes 1..8
- RAID0, InfiniBand
- Shared disk: /RSMtemp
- KVM
- Pre-packaged as a ready-to-use appliance
Parallel RDO is transformative

Workstation

Cluster

Scope to innovate within a day
Newly-optimised design each day

Fewer design choices
Adapt runs to fit project

1 day

1 hour

8 days

8 hours
Test Example

Fujitsu RDO cluster
Press Tool - Overview

• Description
  • This press tool is a part of a hydraulic press. It is guided by four poles and loaded with pressure.
  • Manual geometry and load case variation

• Objectives:
  • Find out the minimum radius in the cylinder
  • Understand influence of pressure load to stresses in adapter
  • Mass reduction considering Total deformation and stresses

• Parameters:
  • 2 variable parameters in the CAD geometry
  • 5 load parameters (2 pressure and 3 force parameters)
Results - Overview

- How to minimize the Radius (increased contact area) without exceeding max. stresses?
  - The variation of the radius has no influence on the maximum equivalent stress of the cylinder.
  - The geometry can be modeled with a radius of 4 mm in this area.
  - Critical stresses are dominated by the fluid channel.
Results - Overview

- Understand influence of pressure load to stresses in adapter
  - Pressure load variation from 10 MPa to 30 MPa
  - Stresses in adapter:
    - Nonlinear behavior between the pressure load and maximum principal stresses
• Bar width variation from 0 mm to 25 mm
  • The bar width has a linear influence on the total mass of the pressing tool.
  • Because of the increasing bar width, the total deformation decreases slightly nonlinearly.
  • Due to a decreasing deformation, the max. principal stresses in the adapter decrease nonlinearly.

• Easier evaluation of multiple parameters by systematic multiobjective optimization to reduce
  • Mass
  • Total deformation
  • Max. principal stress of the adapter
Setup Strategies

a
„send to cluster“
all cores of all compute nodes available
job scheduler to distribute DP‘s

b
„arrange resources“
restrict number of cores of all compute nodes
no DP’s across compute nodes

Workbench-Setting (User)

RSM-Setting (Admin)

c
„minimize communication loss“
Setup Strategies

run parallelization  submission/file transfers

a
„send to cluster“

b
„arrange ressources“

c
„minimize communication loss“

- (too many per node)

- (too many at the same time)

+ (immediate)
Speed Up

![Graph showing speed up versus simultaneous runs with lines for scaling a, b, and c.](image)

- Scaling a: 3.7
- Scaling b: 3.3
- Scaling c: 7.6
- Simultaneous runs: 1 to 8
Sensitivity Study

- Going for RDO
CADFEM/Fujitsu RDO Cluster Strategy

„simultaneous – not sequentially“

„ready to use hardware+software“
You are welcome to contact CADFEM or Fujitsu for a trial of High Performance RDO

- Ian Godfrey
  ian.godfrey@fr.fujitsu.com
  Fujitsu Systems Europe, Toulouse

- Lars Krüger
  lkrueger@cadfem.de
  CADFEM Grafing
Simplify HPC to lower cost and risk, and increase access.
Minimizing Data Transfer
Minimizing Data Transfer to/from the RSM

• When calculating simultaneous design points, all design points are created as archived projects at the local machine as an archive of the current project before submitting to the RSM. As the archives are submitted to the RSM, the file size ought to be as small as possible. Yet, the archived design points contain all data (e.g. rst-file) from the current design point. Therefore, the data files size transferred to/from the RSM needs to be minimized.

• There are two steps for best performance:

1. Set a user variable
   • After setting the user variable, only the scalar values for the Parameter Manager are transferred back after calculation

2. Manual Clearing of the Current Design Point in the Mechanical Editor
   • Before updating all designs, clear the current design point in the Mechanical Editor and save the project. The archived design point projects will not contain large file data (rst-file, …). The transfer to/from the RSM is accelerated most with this option.
Set User Variable
Set User Variable

• Name of Variable:
  ANSYS_FRAMEWORK_ENABLE_REDUCE_RSM_FILE_TRANSFER

• Value of Variable: 1
Manual Clearing of Current Design Point

• Example: Harmonic Response Analysis

• File Size of each archived design point before clearing: ~ 2 GB
Manual Clearing of Current Design Point

• Example: Harmonic Response Analysis

1. Open Mechanical Editor
2. Click RightMouseButton the Solution cell
3. Proceed „Clear Generated Data“
4. Repeat step 1 - 3 for all solution cells
5. Save Project
Manual Clearing of Current Design Point

- Example: Harmonic Response Analysis

- File Size of each archived design point after clearing: ~ 4.5 MB
Mechanical APDL and Simultaneous Calculation
Analysis Selection + Adding Input File

1. Drag and drop “Mechanical APDL“ analysis in the Project Manager
2. Add Input file to the Mechanical APDL analysis (RightMouseButton RMB)
Input and Output Parameter Selection

3. Double click “Analysis” to enter the file overview
4. Click the added file to display the properties and select Input and Output parameters
   → Parameter Set is available
5. Click “Analysis” once or RMB “Properties“ for analysis properties
6. Check, if the update option “Run in Foreground“ is selected → necessary for simultaneous processing
Simultaneous Design Point Processing Options

7. Click “Parameter Set” once to select the simultaneous design point setup
Notice: These settings overwrite the general settings (previous slide), e.g. “number of processors” or “distributed option”.

8. Configure the simultaneous design point process as seen in the section “General Usage” of this document
9. Double click the “Parameter Set”
   → All selected parameters (Input and Output) are available in the Parameter Manager

10. Add design points to the “Table of Design Points”

11. Save Project

12. Click “Update All Design Points”
Example Setting for:

- Simultaneous calculation of 4 design points
- Parallel calculation with 8 cores for each design point
- Background solving
optiSLang Settings for optimal Design Point Calculation
Job Limitation – 3 Ways to Adjust

- Job1
- Job2
- Job3
- Job4
- Job5
- Job6
- Job7
- Job8

RSM Limiter

optiSLang

Parameter Set
optiSLang and Setup 2
Job Limitation – Adjustment for Setup 2

- RSM Limiter
- optiSLang
- Parameter Set

Jobs: Job1, Job2, Job3, Job4, Job5, Job6, Job7, Job8
Setup 2: Local Pre/Post and Remote Solve Process and optiSLang

Solution

Parameter Set

DOE
Job Limitation – Adjustment for Setup 3

- RSM Limiter
- optiSLang
- Parameter Set

Jobs:
- Job1
- Job2
- Job3
- Job4
- Job5
- Job6
- Job7
- Job8
RSM Setting in optiSLang for Setup 3

- Activate RSM Mode
- Specify „Number of Design Points in Parallel“: 64 (keep it always as a fixed number, even if there are less design points to calculate!)
Setup 3: „Specify Maximum Number of Jobs“ – 3rd Type and optiSLang

**Solution**

**Parameter Set**

**DOE**
Good to Know
In Windows the maximum length of a path/name is limited to **256 characters**. In case of exceeding this limit design points cannot be transferred back from the remote computer even if they are calculated correctly.

*Keep the path and name as short as possible!*

**Path Structure:**
- **Verzeichnispfad\Dateiname_pending_tasks\UpdateDesignPoints-x\Dateiname_updated_dpx.wppz**

**Examples:**
- **File name:** optiSLang_xxxxx_Test_mosl_3rdV  
  **Path:** D:\nnagl\optiSLang-Test\optiSLang_xxxxx_Test_mosl_3rdV_pending_tasks\UpdateDesignPoints-2\optiSLang_xxxxx_Test_mosl_3rdV_updated_dpx.wppz  
  → 139 characters

- **File name:** sensi2_xx_adv_30Apr2014_fuer_Sensitivitaetsanalyse_mit_Parameterraum_u3_75_v7mp_Gerechnet  
  **Path:** D:\nnagl\optiSLang-Test\sensi2_xx_adv_30Apr2014_fuer_Sensitivitaetsanalyse_mit_Parameterraum_u3_75_v7mp_Gerechnet_pending_tasks\UpdateDesignPoints-xxx\sensi2_xx_adv_30Apr2014_fuer_Sensitivitaetsanalyse_mit_Parameterraum_u3_75_v7mp_Gerechnet_updated_dpxxx.wppz  
  → 259 characters
Setup 3 – Transfer of Additional Data to Remote Computer

• Put all necessary data (e.g. input files, material data, …) in the user_files folder. This folder is copied to the remote computer.

• Use relative paths instead of fixed ones
Use ONE unit systems for ALL analyses. If you assign the unit system in the analysis setting manually, do it for ALL analyses!