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Coupling technology benchmarking in IS-ENES2

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Coupling technology benchmarking in IS-ENES2

WP10-T3 Evaluation of coupling strategies; CERFACS, MetO, STFC, UNIMAN, DKRZ

Objective: Define a suite of coupled benchmarks based on simplified components, which capture the essence of the coupling without the science complexity

1. Capture functional and performance characteristics of coupling system
2. Code a set of simplified components reproducing these characteristics
3. Implement the coupling between these components with OASIS and ESMF.
4. Run the benchmark suite on specific platforms.
5. Analyse results and present them to the community,
6. Undertake performance modelling to support the analysis of the benchmark

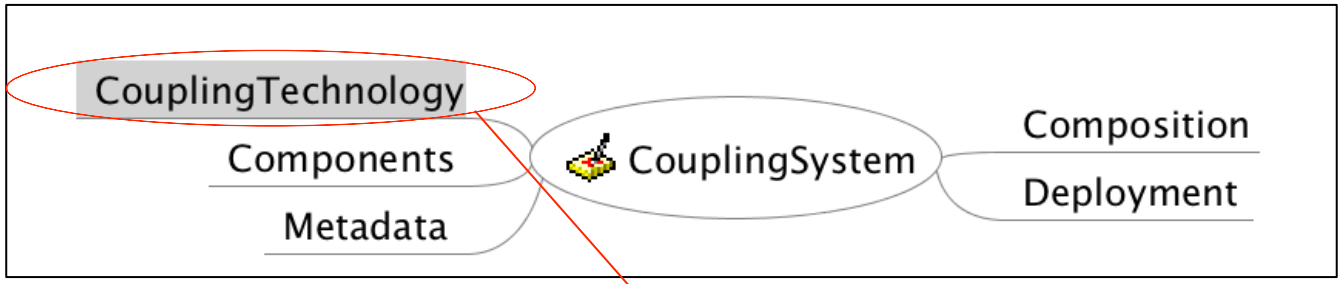
➢ D10.3 Report on benchmark suite for evaluation of coupling strategies

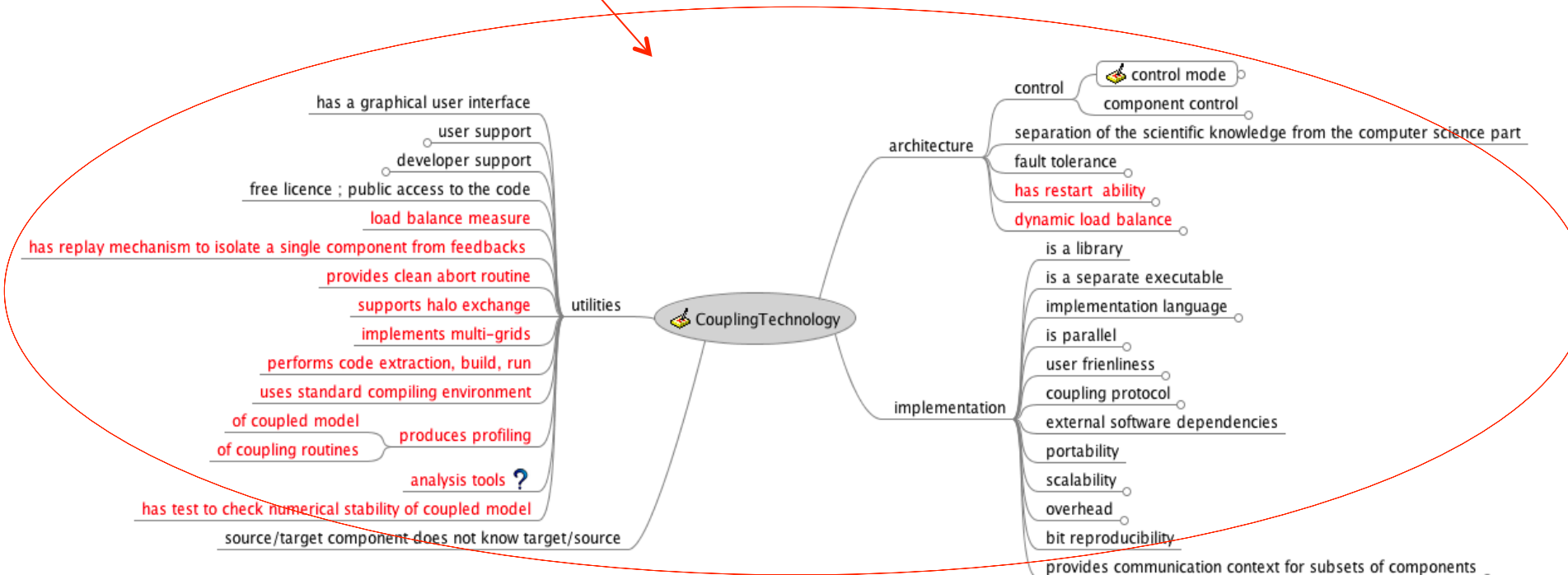
Coupling technology benchmarking in IS-ENES2

1. Capture functional and performance characteristics of coupling system

Working groups at CW2013, Boulder: => exhaustive list of coupling system characteristics

US project Earth System Bridge + 2014 IS-ENES2 Exeter workshop: => mindmaps





Coupling technology benchmarking in IS-ENES2

1. Capture functional and performance characteristics of coupling system

- ✓ Priority coupling characteristics to benchmark
  - Type of the component grid
  - Number of cores per component
  - Numbers of fields exchanged
  - Frequency of exchange
  - Size of the coupling fields
  - (Ease of use: code intrusion, development time, techniques for overcoming specific issues)

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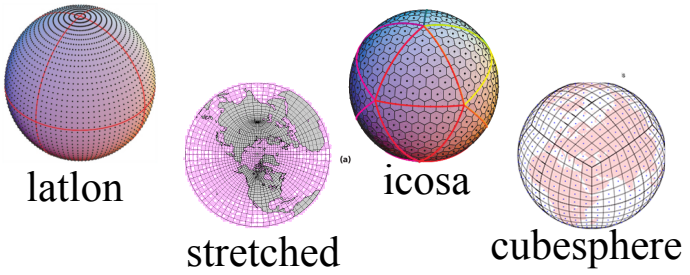
2. Code a set of simplified components reproducing these characteristics

- ✓ 4 stand alone components on 4 different grids available on bitbucket.org
  - MPI parallel fortran subroutine(s), no physics/dynamics, real coupling characteristics
  - Coupling fields as IN/OUT arguments, arrays in shared modules, local data
  - Use specific grids
    - *latlon:* latitude-longitude, arbitrary resolution
    - *stretched:* stretched, rotated, logically rectangular, ORCA
    - *icosa:* quasi-uniform icosahedral, e.g. NICAM
    - *cubesphere:* quasi-uniform cubed sphere



In addition

- ✓ Specification of priority test-cases to evaluate the impact of the priority coupling characteristics (possible combinations of all coupling characteristics in almost infinite):
  - Number of cores per component
  - Grid size
  - Ratio of the number of cores/component
  - Schedule and layout
  - Number of coupling fields

➢ Milestone (M10.4) “Implementation of the benchmark suite for evaluation of coupling strategies”

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3. Implement the coupling between these components with OASIS and ESMF.
4. Run the benchmark suite on specific platforms.

What we tested: impact of grid size and number of cores/component:

- On 3 platforms: Bullx Occigen (Fr), MetOffice Cray (UK), Marconi Broadwell (It):
  - For 4 coupling technologies, OASIS, ESMF, Open-PALM, YAC
    - For 1 couple of grids: regular latlon with same rectangle decomposition
      - For 3 couple of grid sizes: LR-HR, HR-HR & VHR-VHR
        (LR:100x100, HR:1000x1000, VHR: 3000x3000)
        - For at least 5 numbers of cores/comp O(1, 10, 100, 1000, 10000)

➢ Minimal number of runs for this (simple) test case: 3x4x1x3x5 = 180

In addition: impact of opposite decompositions (on Bullx Occigen only):

- For OASIS, ESMF, Open-PALM, YAC
  - for regular latlon grids with opposite decomposition
    - for 3000x3000 (VHR-VHR);
      - for O(1, 10, 100, 1000, 10000) cores/components

➢ Minimal number of runs for this test case on Bullx: 4x1x1x5 = 20

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WP10-T3 Evaluation of coupling strategies; CERFACS, MetO, STFC, UNIMAN, DKRZ

Objective: Define a suite of coupled benchmarks based on simplified components, which capture the essence of the coupling without the science complexity

1. Capture functional and performance characteristics of coupling system
   - ✓ CW2013 & interaction with US project Earth System Bridge
2. Code a set of simplified components reproducing these characteristics
   - ✓ 4 stand alone components on 4 different grids available
3. Implement the coupling between these components with OASIS and ESMF.
   - ✓ Coupled system for regular grids with OASIS, ESMF, OpenPALM, MCT and YAC
4. Run the benchmark suite on specific platforms.
   - ✓ Test cases run on Bullx Occigen (Fr), MetOffice Cray (UK), Marconi Broadwell (It)
5. Analyse results and present them to the community,
   - ✓ On-going
6. Undertake performance modelling to support the analysis of the benchmark
   Needs benchmarking results

➢ D10.3 Report on benchmark suite for evaluation of coupling strategies
   Coming soon!

Summary & perspective

- ✓ Very interesting international collaboration for capturing the characteristics of coupling systems
- ✓ Defining the specifications of the first benchmark version:
  - far more complex than expected
  - very touchy to define standard and unbiased specifications
- ✓ Results of first benchmark version are available for Bullx Occigen (Fr), MetOffice Cray (UK), Marconi Broadwell (It)

- ➢ Announce availability of this first IS-ENES2 coupling technology benchmark
- ➢ Write-up the deliverable D10.3
- ➢ Analyse all results in depth, write and publish a paper

Many thanks to Gabriel, Mike, Andrew, Graham, Rupert and Moritz for their energy in this very challenging collective work

The end

Coupling technology benchmarking in IS-ENES2

1. Capture functional and performance characteristics of coupling system

Working groups at CW2013, Boulder:

- *What are the **scientific and technical requirements** […] to **build a geophysical coupled system from independent models**?*
- *What are the **qualities** that should be **assessed in a coupling technology benchmark** and how should those qualities be **measured**?*

✓ Exhaustive list of coupling system characteristics

Data exchange and redistribution	
• Exchange between different models with different decompositions or within same model with same or different decompositions	• Yes/No • Types of grids supported • Masked grid supported (yes/no) • Types of decompositions supported • Local or global knowledge of decomposition • How easy to describe the decomposition • MOTR[1] for computation of communication patterns • MOTR for data exchange (for difficult test cases e.g. 40+ 3D fields every time step or load imbalanced cases)
• Exchange of data with halo	• Yes/No • Halo extension (one neighbor, more?)
• Support of adaptive grids	• Yes/No
Regridding and weight generation	
• Regridding of coupling data, sparse matrix multiplier	• Yes/No • Types of regridding supported • Dimensionality supported (2D, 3D, etc) • Types of grids supported • Types of decompositions supported • Externally generated weights supported • MOTR for regridding (performance) • Flexibility / ease of use •
• Regridding weight generation	• Yes/No • Types of regridding supported • Types of grids supported • Types of decompositions supported • Masked grids supported? • *MOTR for weight generation (performance)*
• Weight generation for non geometrical regridding (e.g. runoffs, catchment basins, calving)	• Yes/No • *MOTR for weight generation*
Mediation on coupling data	
• Averaging, accumulation	• Yes/No • *MOTR for operation*
• Combination of coupling fields	• Yes/NO
• Land-ocean coastline consistency checking	• Yes/NO

• Other types of mediation	• Yes/No, which ones
Time integration features	
• Implicit coupling	
• Calendar, clock	• Yes/No • Types of calendars • Length of time
Output handling	
• Coordinated stdout and stderr	• Yes/No • Human readable output?
• Online diagnostics	• Yes/No • Flexible, configurable?
• Output of state time	• Yes/No • Flexible, configurable?
• Diagnostics mediated with regridding, combinations, etc	• Yes/No • Regridding accuracy
Workflow support	
• Code extraction, build, run	• Yes/No • MOTR excluding runtime
• Configuration management	
• Cross model restart ability	
• Support for restart on system signal	
• Ensemble support including fault tolerance.	
• Coupled system launch support on complex parallel hardware	
• Archiving data	
• Case management	
Others	
• Encapsulation of different parts of the scientific code, separation of scientific knowledge from the "computer science" (e.g parallelism)	

Portability and performance	
• Portability, standard compliance	• Number of compilers complied with
• OS compatibility	• Number of platforms run on
• Multi-language support, language compatible with ESM	• Number of languages framework callable from
• Support for hybrid modes - openMP	• Yes/No
• Conformance to conventions (e.g. grid conventions)	• Yes/No, which ones:
• Memory impact , memory scalability of distributed data types	• Measure of memory impact
• Scalability	• Results of latency and bandwidth tests
• Low overhead	• Measure of overhead; compare different frameworks with same models
• Bit reproducibility	• Yes/No; details
• Fault tolerance	•
• Analysis tools	• Yes/No
• Dynamic load balancing	• Yes/No; how:
• Load balance measure	• *Measure performance of optimized result-- learn from HPC suppliers*
User support	
• Documentation / user guide	• Yes/No
• Human support by developers (mail, phone, etc)	• Yes/No • Average response time? quality
• Quality of prioritization process (feature requests)	•
• Community support	• Yes/No; how
• Code readability	• Poor/medium/high
Coupled model developer support	
• Range checking on input values/fluxes – outlier detection – validation checks	• Yes/No
• Profiling available	
• Debugging included, possibility to use with debuggers	• For the software • For the science
• Error handling	
• "Replay" mechanism to isolate a single component from feedbacks	
• Idealized test cases to check conservation, interpolation order	• Check mark exists? Tested?

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1. Capture functional and performance characteristics of coupling system

- ✓ First series of mindmaps by US project Earth System Bridge reviewed during IS-ENES2 Exeter workshop (Feb 2014)

EARTH SYSTEM BRIDGE