Objective 2: Models, Tools and HPC

WP4/NA3:
Networking on Models, Tools and efficient use of HPC

WP4-Task3: Complex Coupled Systems HPC performance evaluation

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Main goals

- **Collect and define new metrics to generate analyses to reduce the cost of each component independently and an Earth System Model as a whole**
- **The results will differentiate load-balancing, component-interaction and single component issues**
- **Integrate metrics and analysis suggestions in community tools (improve LUCIA/OASIS3-MCT)**

WP4-Task3 Summary

- WP4-Task3 will perform a complete computational and energy performance analysis of CMIP6 models using the CPMIP metrics
  - A set of metrics thought to study the computational performance of climate models (Balaji et al. 2017).
- The task will move beyond traditional metrics and expand the database with a systematic collection of performance results from IS-ENES3 partners.
- New metrics: energy consumption using low-level utilities.
- Advise on applying profiling tools and interpreting the results.

Issues which require interaction and coordination

- Coordination with people working to improve and expand CPMIP metrics
- Coordination with ESM developers to integrate CPMIP metrics in the environments
- Coordination to systematically collect metrics from CMIP6 experiments
  - From IS-ENES3 partners laboratories
  - From other community/external partners

WP4-Task3 Summary

- Load-balancing of coupled models is one of the greatest computational performance challenges for the ESM community.
- A load balancing and affinity/binding distribution study will be done in order to provide recommendations to minimize the idle-time in a range of OASIS-based coupled components
- The study will cover particularities of coupled models
  - Irregular time steps, variety and wide range of component speeds and sequencing constraints.
- Creation of new metrics and an analysis method to integrate in LUCIA and provide recommendations for each ESM

Issues which require interaction and coordination

- Interaction with OASIS/LUCIA developers
- Coordination with ESM developers to understand the particularities of each coupled model (components interaction and single component issues)
- Coordination to launch the selected ESMs and collect results from different environments

WP4-Task3 Open questions

- **CPMIP metrics** and load balance evaluation must be representative and useful for a wide variety of our community ESMs
  - How many ESMs are relevant enough to include?
  - CPMIP collection: Which ESMs and configurations should be included to have a complete evaluation of the computational performance of our models?
  - Is it possible to separate computing performances and other geophysical metrics?
  - Systematic strategy collection: Which institutions will participate, which type of support they should expect from us, could participants have access to the database?
  - Could we have hardware constraints? Which ones should be taken into account?
  - Where to publish (Web page, interaction with ES-DOC)?

WP4-Task3 Open questions

- CPMIP metrics and **load balance evaluation** must be representative and useful for a wide variety of our community ESMs
  - How many ESMs are relevant enough to include?
  - Component-interaction: Which ESMs are needed to cover a high range of possibilities?
    - Type of coupling, volume of fields exchanged
    - Irregular time steps
    - Variety of component speeds (different scalability curves)
    - Sequential constraints
  - Single component issues (IO, sea-ice…): Which ESMs are needed to cover?
  - Could we have hardware constraints? Which ones should be taken into account?
  - Where to publish (Web page, interaction with ES-DOC)?

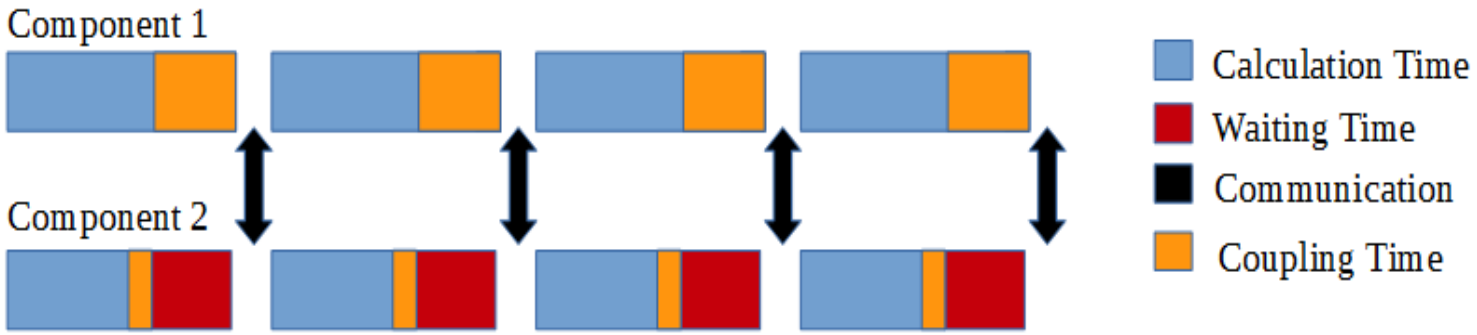
- Support material not included in the presentation

Load balancing Case Example

- Extent LUCIA functionalities to take into account more cases
- Provide a method to suggest to the users the best configuration (for a given number of parallel resources) to balance a coupled model
- The new metrics needed and possible methodology (to reduce to the minimum the waiting time among components) will be studied through IS-ENES3.
- However, it is critical to set which ESMs should be studied so the new metrics are useful for all possible community configurations.

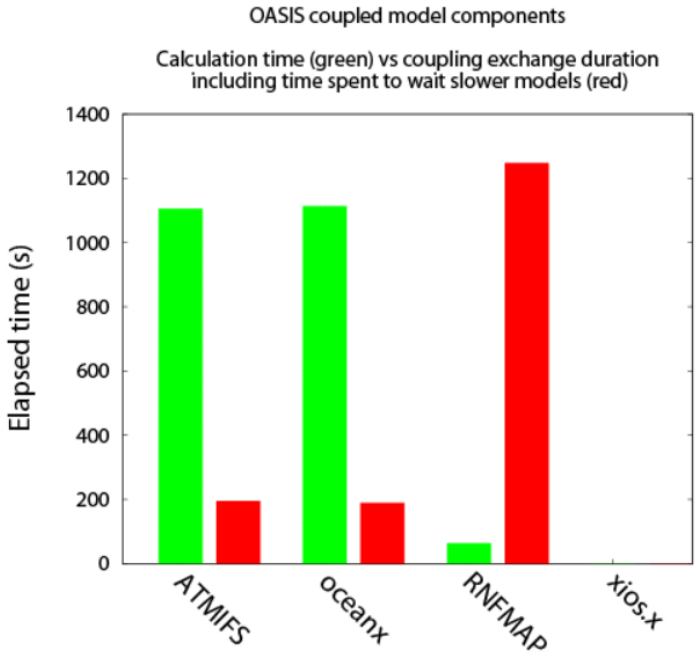
Load balancing Case Example

- Find a load balance among the main components of a coupled model is mandatory to optimize the resources used.
- Some configurations are simple, the slowest component is the important to set up the coupled computational efficiency.
- For others, achieve a similar SYPD for the main components is good enough to achieve a good load balance.



Load balancing Case Example

- Load balance among components of climate models
  - LUCIA: A tool provided with OASIS3-MCT to analyze coupling exchanges



Calculation + Coupling → **Cn**

Communication + Waiting → **En**

Load balancing Case Example

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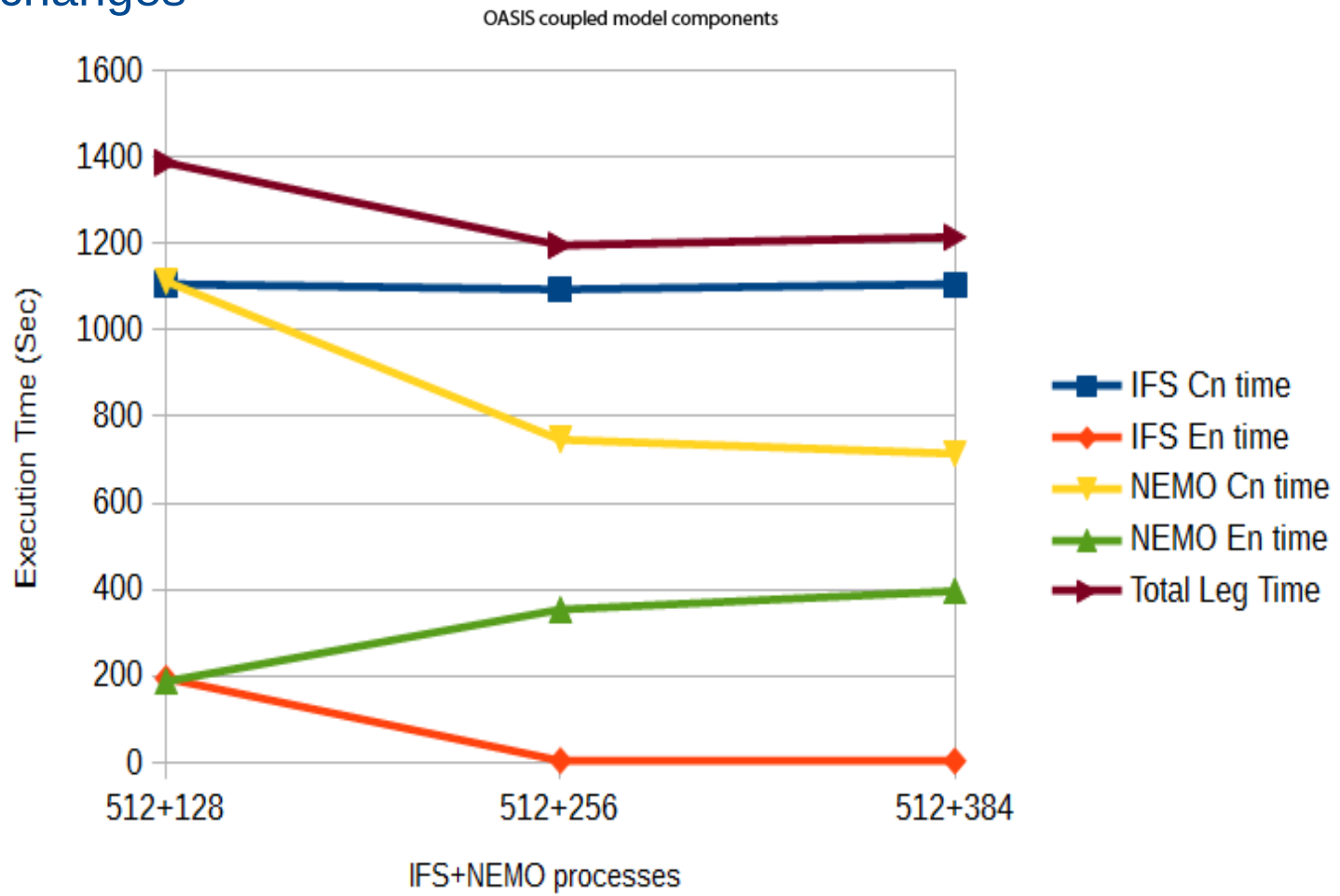
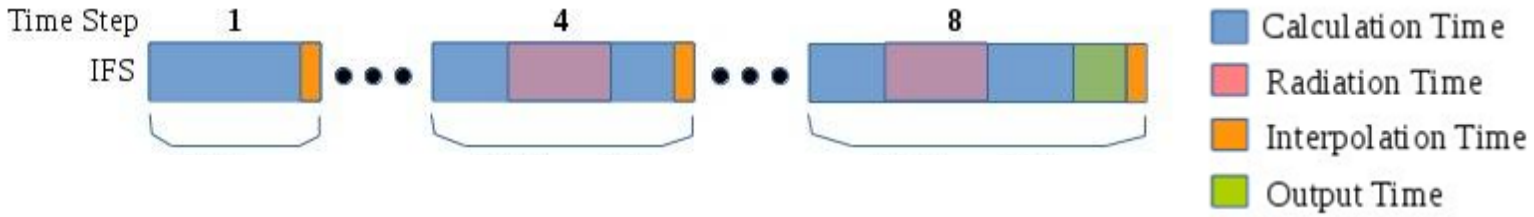
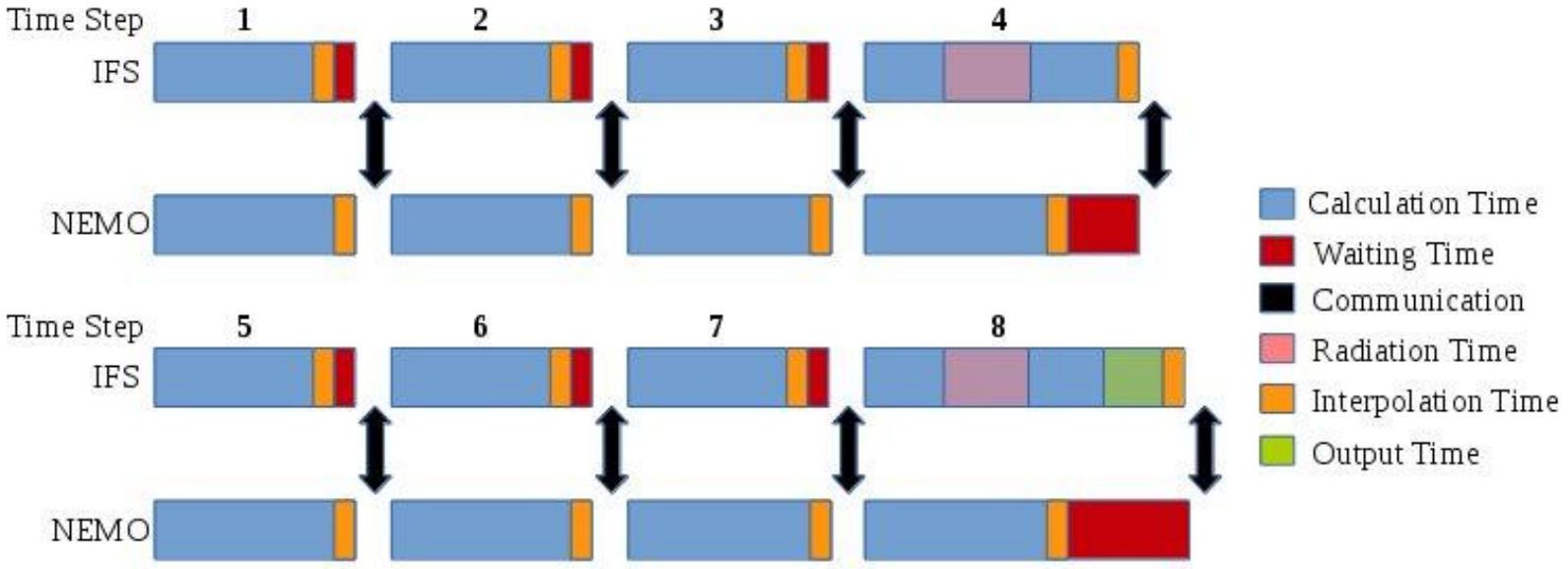


Load balancing Case Example

- IFS execution time step is not regular



  - Six per eight time steps are regular
  - One per four time steps calculates radiation
  - One per eight time steps produces outputs



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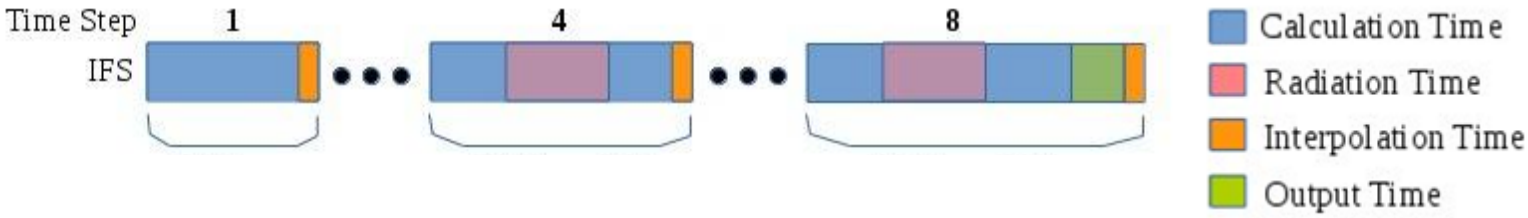

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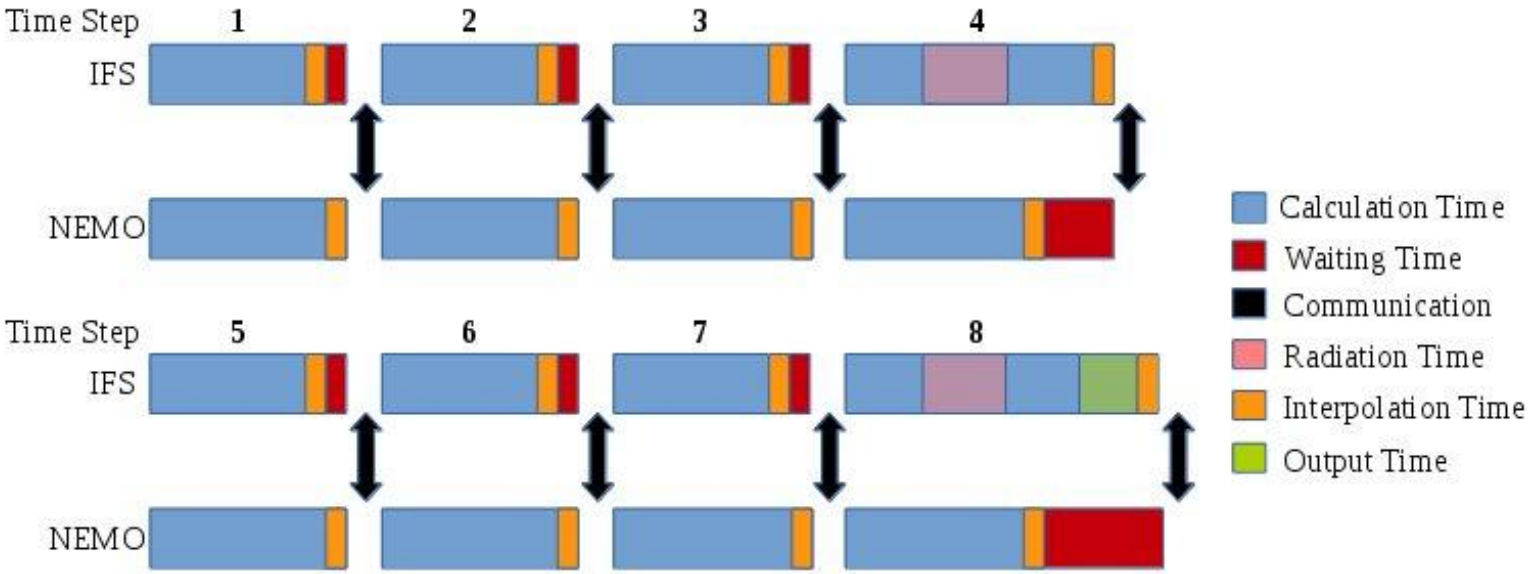
- LUCIA metrics or any other metrics which use total or average execution time are not enough for climate models with irregular coupling time steps of one or more components.

Load balancing Case Example

- Case 1: Cn_{IFS} and Cn_{NEMO} are equal

	1	2	3	4	5	6	7	8	Rts	Cn	En	Tex
Case1 (IFS)	70	70	70	105	70	70	70	125	70	650	135	785
Case1 (NEMO)	81.25	81.25	81.25	81.25	81.25	81.25	81.25	81.25	81.25	650	135	785
Case2 (IFS)	70	70	70	105	70	70	70	125	70	650	0	650
Case2 (NEMO)	70	70	70	70	70	70	70	70	70	560	90	650

Tex: Total execution



Load balancing Case Example

- Case 1: Rts_{IFS} and Rts_{NEMO} are equal

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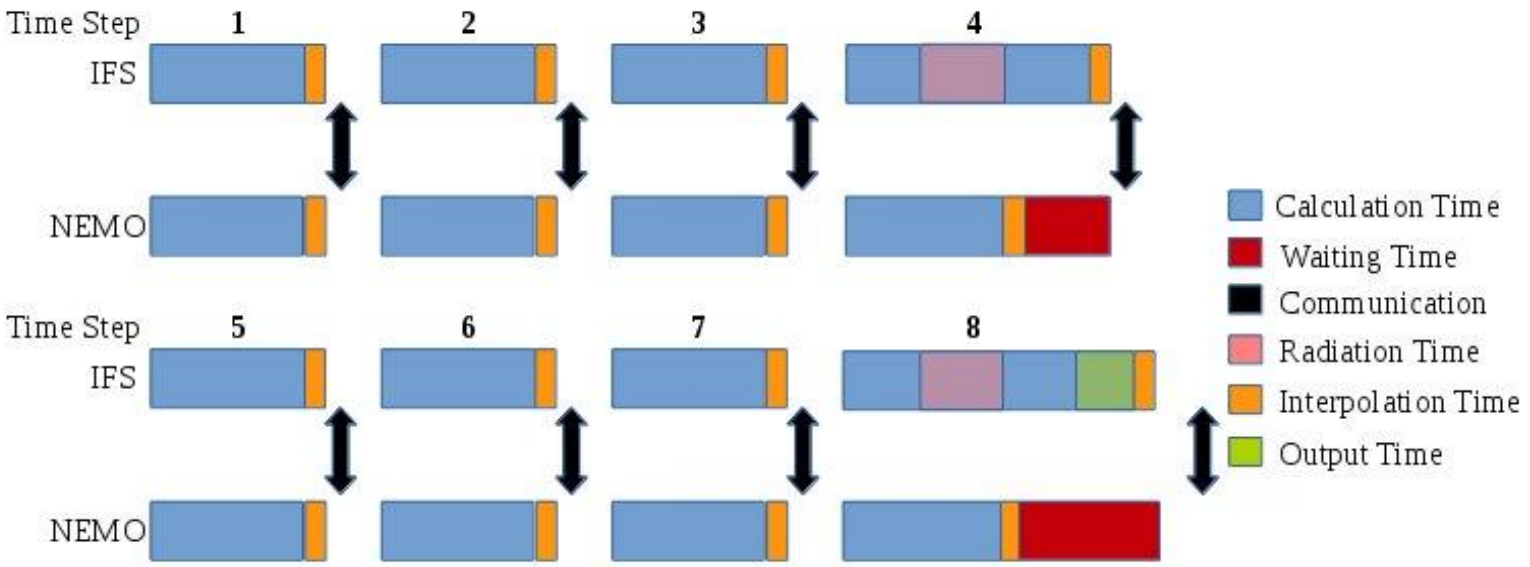

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