A Virtual Imaging Platform for the Virtual Physiological Human

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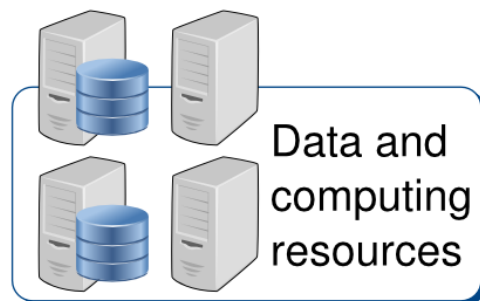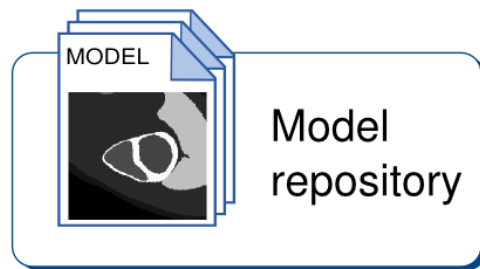Centre for Computational Science
University College London

VPH 2012 Conference
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London, UK

Overview

- The Virtual Imaging Platform – VIP

- Exemplar Project – VIP for VPH

- Interface with the VPH Toolkit

- VIP for VPH in action

- Concluding remarks

The Virtual Imaging Platform - VIP

Application software

- Multi-modality medical image simulators: MRI, US, CT, and PET.

- Simulators described as workflows.

MODEL
Model repository

- Geometric definition and physical parameters such as proton density, echogenicity, radioactivity, chemical composition.

- Ontologies (ongoing work by INRIA Rennes).

Data and computing resources

- European Grid Infrastructure (EGI).

- Biomed Virtual Organization.

The Virtual Imaging Platform - VIP

Application software
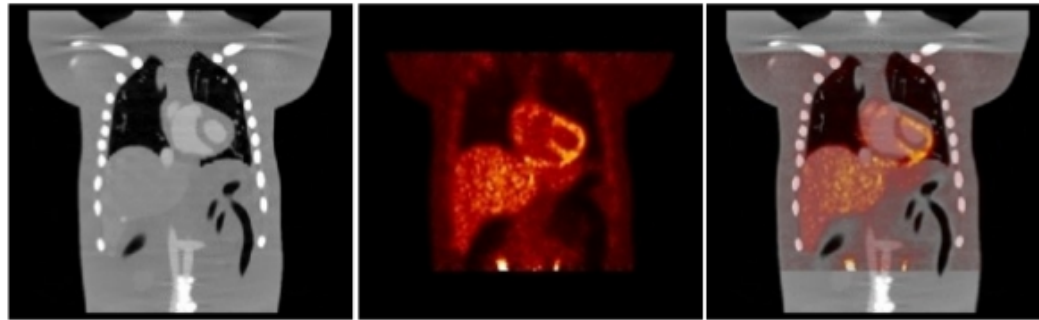

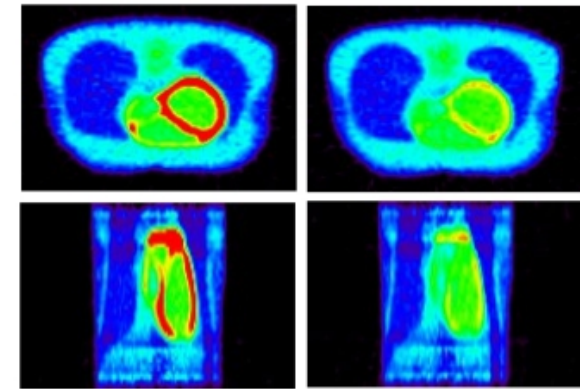Model repository

Data and computing resources
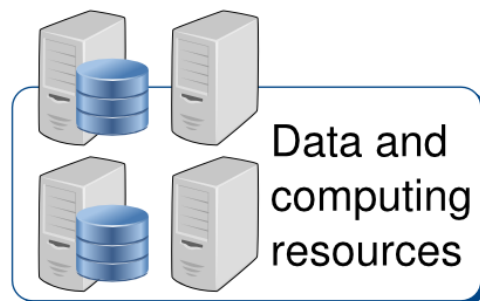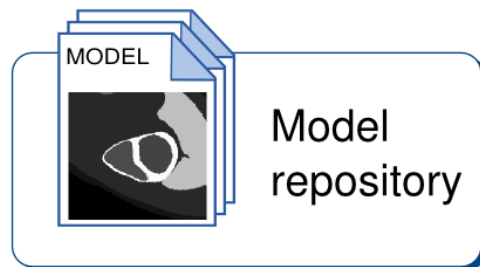
Motivation

- Imaging
  - Test new image sequences
  - Prototype imaging devices

- Image processing
  - Evaluate algorithms (e.g. segmentation)
  - Design realistic human models

- Educational
  - Test sequence parameters
  - Investigate artifacts

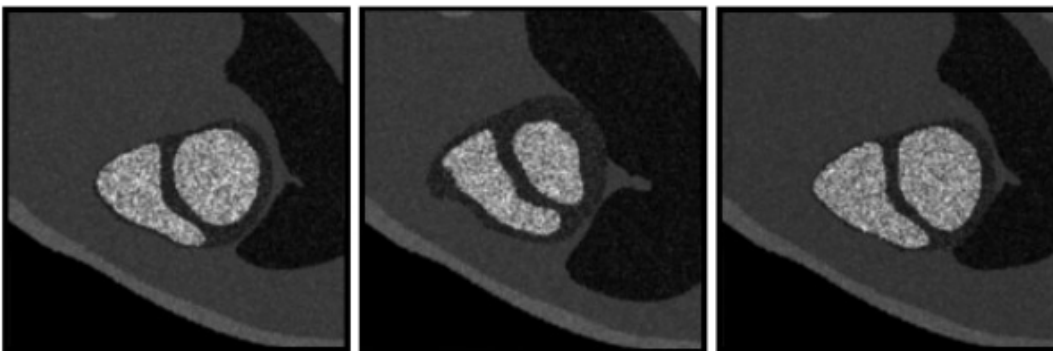# The Virtual Imaging Platform - VIP
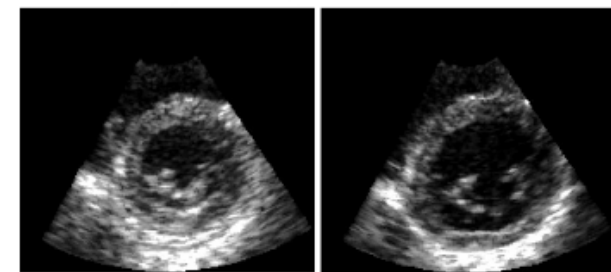
Goal: support heavy simulations.

From left to right: CT, PET and overlaid whole-body simulations

13 h

Three instants of a 2D+t MRI cardiac simulation

7.5 h

FDG-PET simulation of a healthy (left) and pathological heart

91 h

End-systolic (left) and end-diastolic (right) Instants of a simulated 2D+t echocardiography

42 h

The Virtual Imaging Platform - VIP

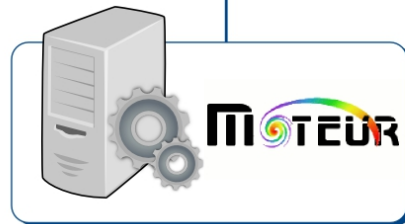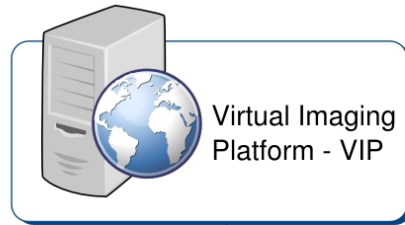## VIP Architecture

VIP - System Architecture

User Front-End

- Openly-accessible web portal.

- Access point to models and simulators.

- User-friendly interface which assist users in using image simulators.

Workflow Engine

- MOTEUR workflow engine.
  `http://modalis.i3s.unice.fr/softwares/moteur/`

The Virtual Imaging Platform - VIP

VIP - System Architecture

VIP Architecture

Workload Management System with Pilot Jobs

- Distributed Infrastructure with Remote Agent Control (DIRAC) [CPPM – LHCB].
  http://diracgrid.org/

Data Storage and Computing Back-End

- EGI infrastructure.
  http://www.egi.eu/
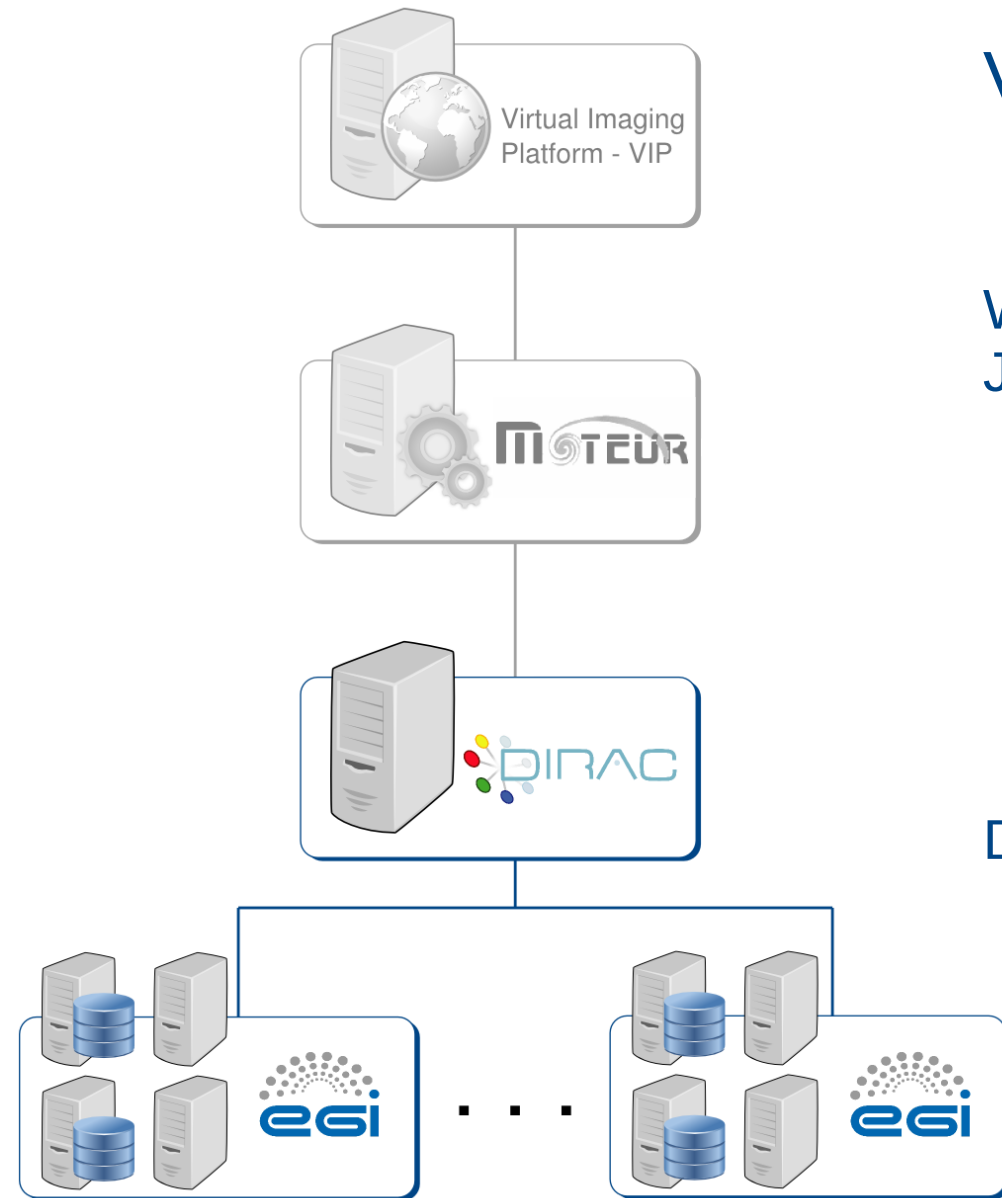
The Virtual Imaging Platform - VIP

VIP - System Architecture

VIP Facts

- **250** registered users, from **25** countries.

- Most used portal certificate in EGI.
  `https://wiki.egi.eu/wiki/EGI_robot_certificate_users`

- Consummed 379 CPU years from January 2011 to August 2012.
  `http://accounting.egi.eu`

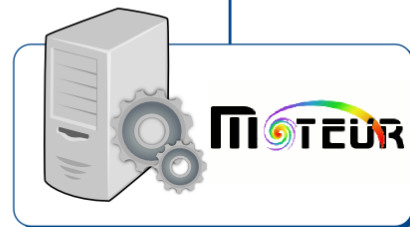- 1/10 of the total activity of the biomed international VO. One of the most active users.
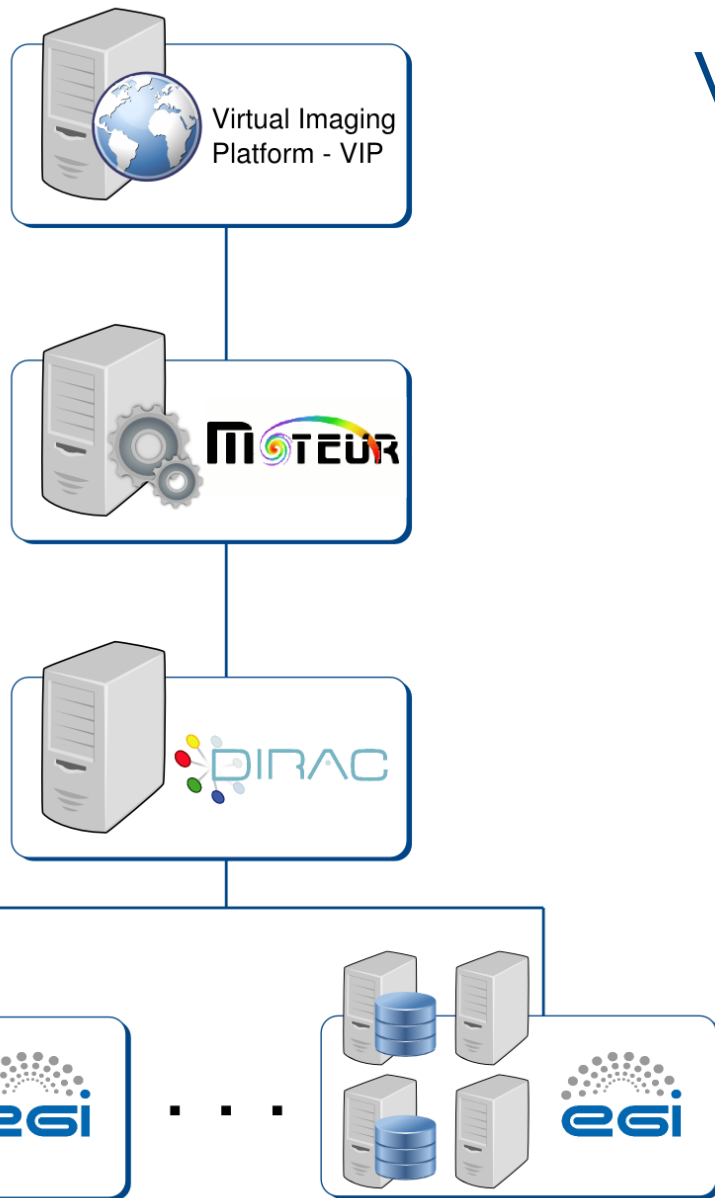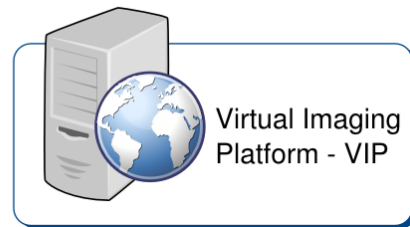
Exemplar Project – VIP for VPH
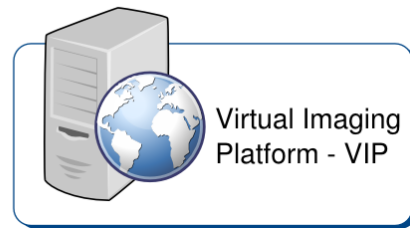
- MPI execution is not reliable on the current infrastructure.

- Execute VIP simulations on PRACE resources (dedicated,MPI).
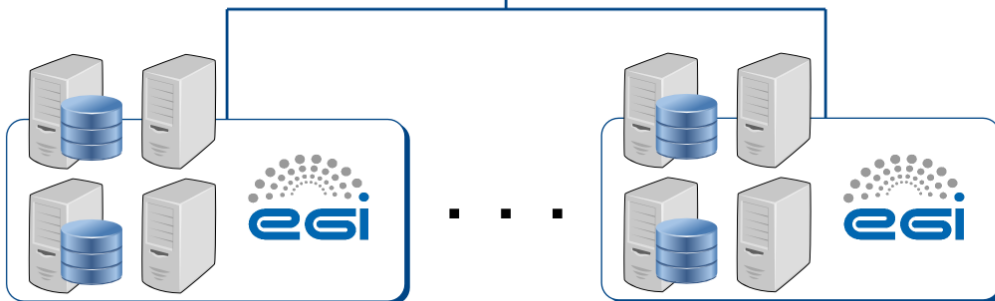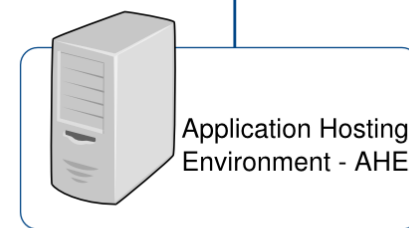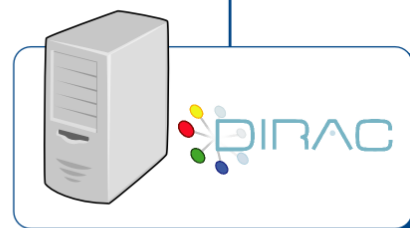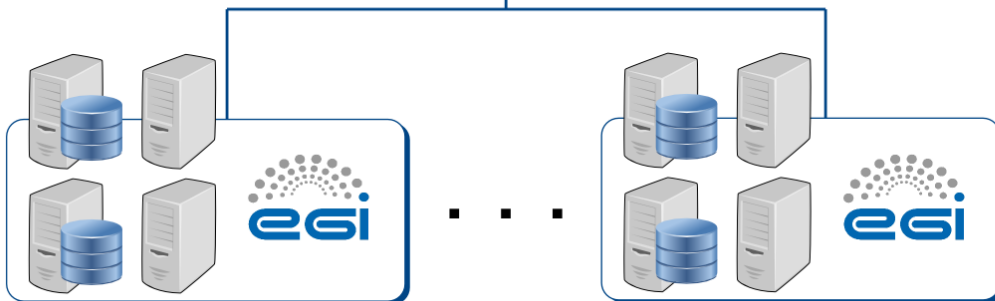
VIP for VPH
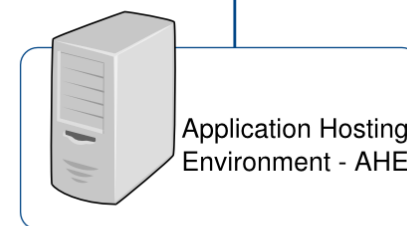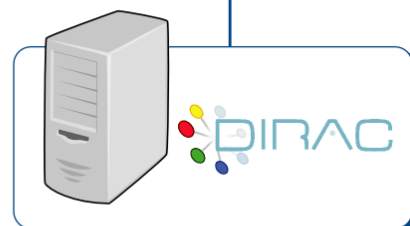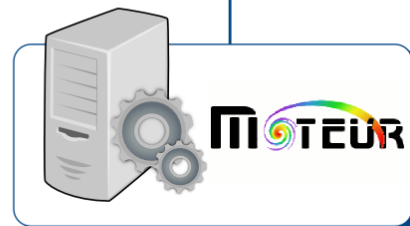System Architecture

Exemplar Project – VIP for VPH

- A mechanism for the execution of medical image simulation workflows on HPC resources through workflow interoperability between the VIP and AHE.
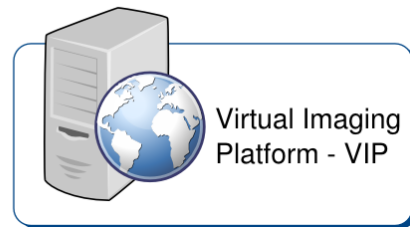
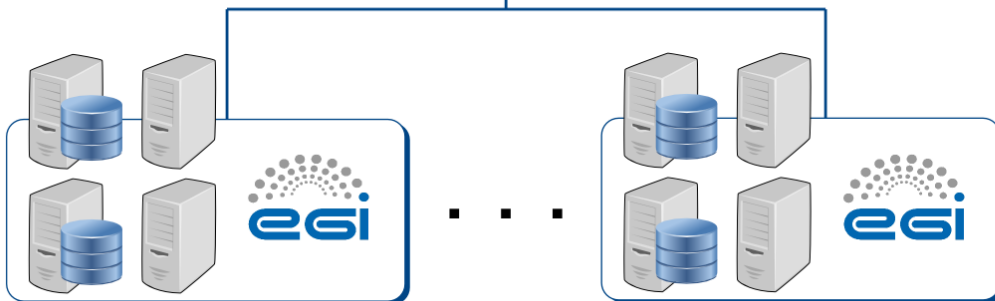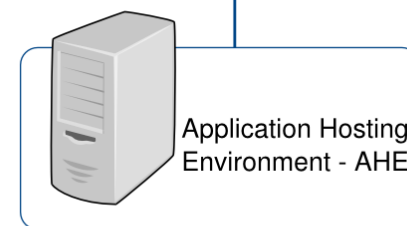- Interface MOTEUR engine with the Application Hosting Environment.
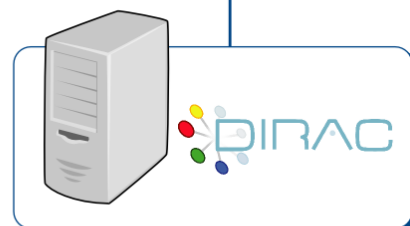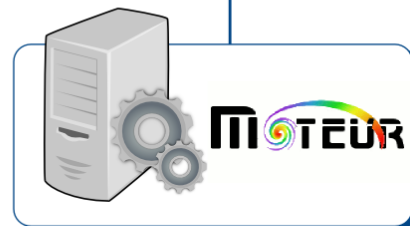 `http://www.realitygrid.org/AHE/`

VIP for VPH
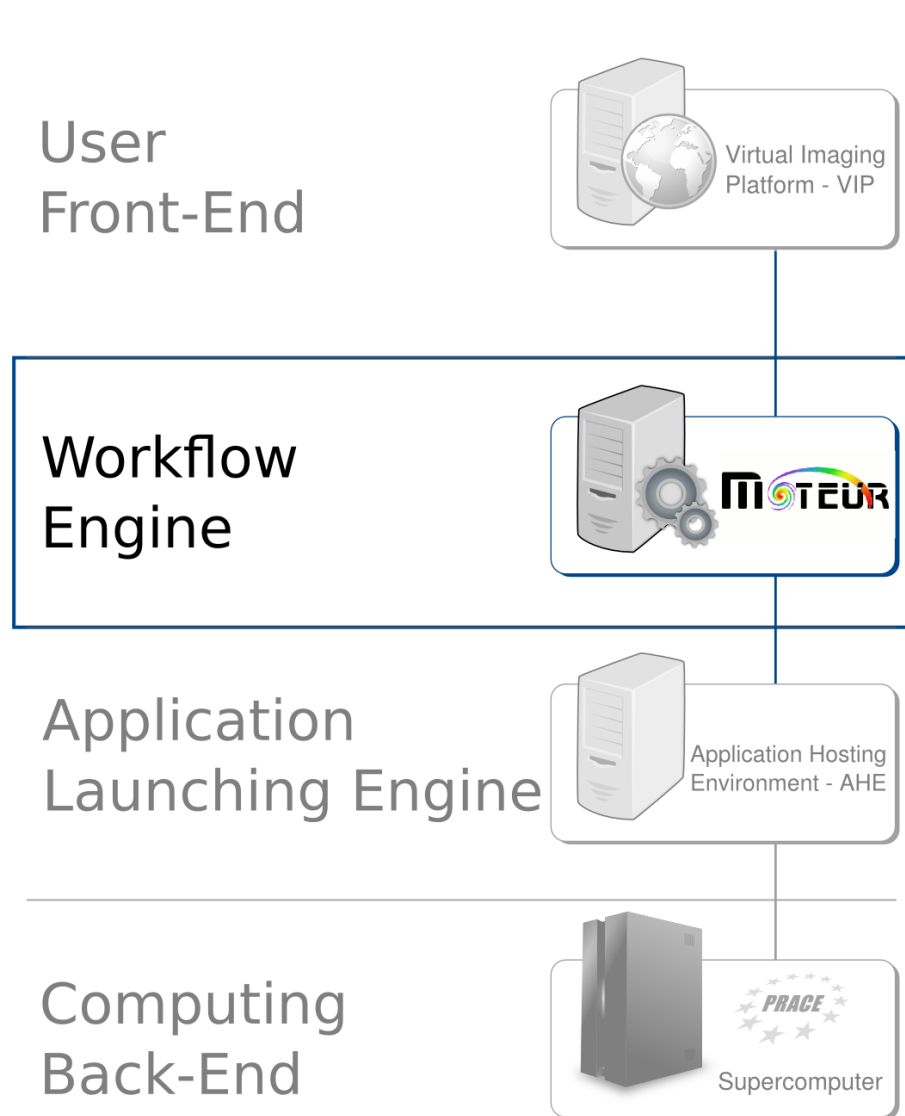System Architecture

Exemplar Project – VIP for VPH

- This work was granted access to the HPC resources of The Edinburgh Parallel Computing Centre – EPCC made available within the Distributed European Computing Initiative by the PRACE-2IP.
  `http://www.prace-project.eu`

VIP for VPH
System Architecture

Interface with the VPH Toolkit

User
Front-End
— Virtual Imaging Platform - VIP

Workflow
Engine
— MOTEUR

Application
Launching Engine
— Application Hosting Environment - AHE

Computing
Back-End
— PRACE Supercomputer

VIP for VPH - System Architecture

MOTEUR

`http://modalis.i3s.unice.fr/softwares/moteur/`

- Generic Application Service Wrapper (GASW) enables to access several Distributed Computing Infrastructures.
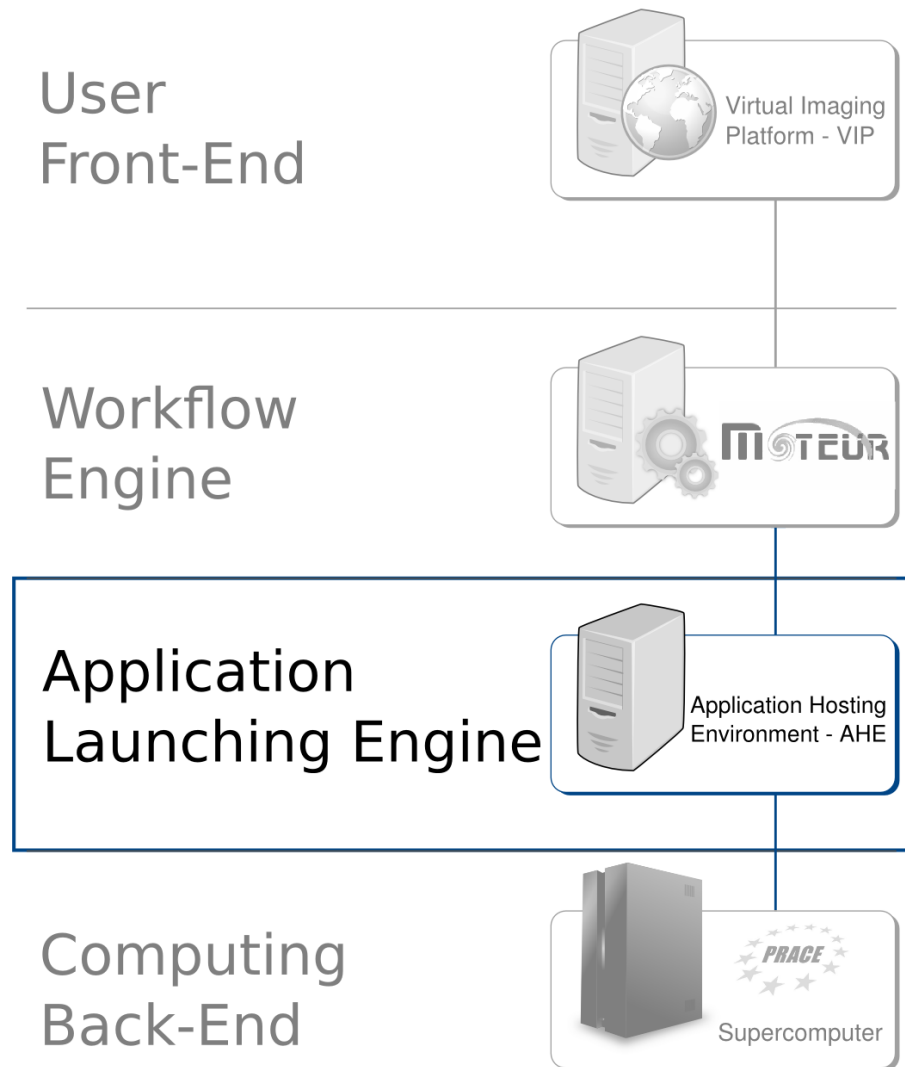 `http://vip.creatis.insa-lyon.fr:9002/projects/gasw`

- The GASW AHE plug-in enables GASW to access AHE resources.
  - Launch and monitor jobs.
  - Data transfer.
  `http://vip.creatis.insa-lyon.fr:9002/projects/ahe`

Interface with the VPH Toolkit

User
Front-End

Virtual Imaging
Platform - VIP

Workflow
Engine

M⊙TEUR

Application
Launching Engine

Application Hosting
Environment - AHE

Computing
Back-End

PRACE

Supercomputer

VIP for VPH - System Architecture

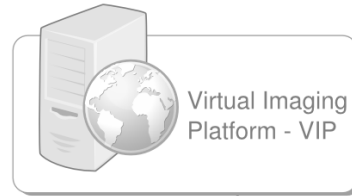## The Application Hosting Environment

`http://www.realitygrid.org/AHE/`

- Part of the VPH ToolKit, freely available to the VPH community.

- Interfaces to back-end middlewares (i.e. Globus 2/4, Unicore 6)

- Manages submission and monitoring of jobs as well as data transfer.

Interface with the VPH Toolkit
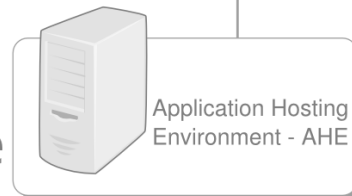
VIP for VPH - System Architecture
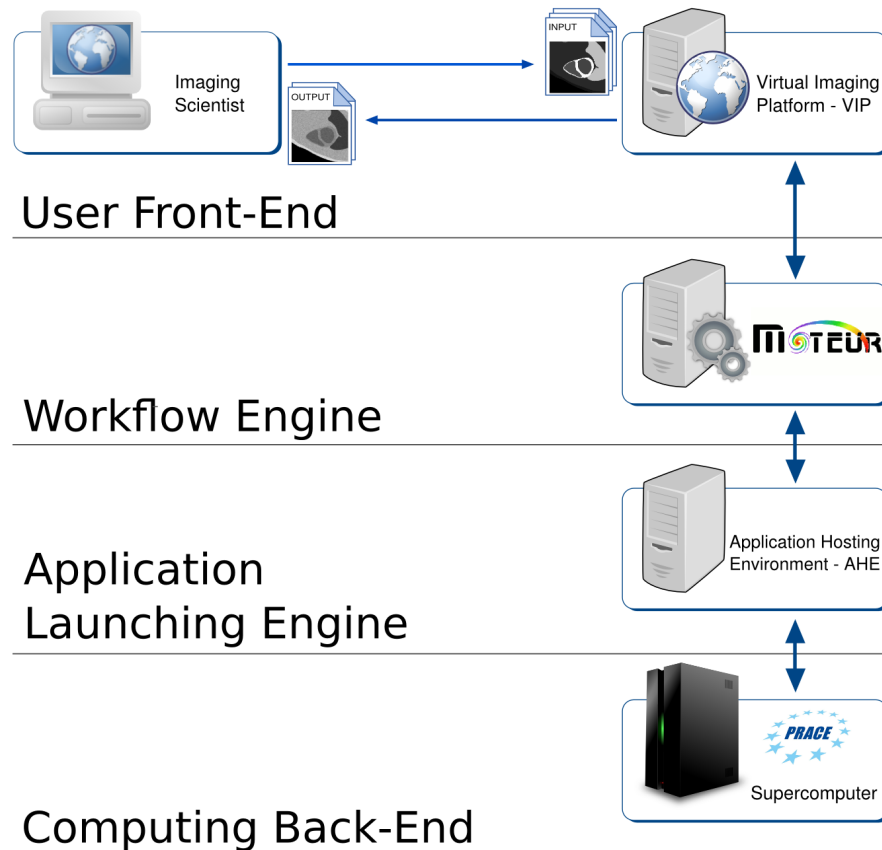

HECToR

`http://www.hector.ac.uk`

- High-End Computing Terascale Resource

- Located at The Edinburgh Parallel Computing Centre – EPCC, UK.

- Cray XE6 system:
  - 90,112 cores
  (AMD Opteron 2.3GHz Interlagos processors)
  - 90 Tb memory
  (Each 16-core processor shares 16Gb of memory)

VIP for VPH in action

User Front-End

Workflow Engine

Application
Launching Engine

Computing Back-End

VIP for VPH - System Architecture

Use Case Scenario

- A heavy MRI simulation

Application Software	*SIMRI –* 3D MRI simulator based on the Bloch equation.
Website	**http://www.simri.org**
Main Algorithm	Solution to linear differential equation. (ODE solver).

VIP for VPH in action

Use Case Scenario – Model 1
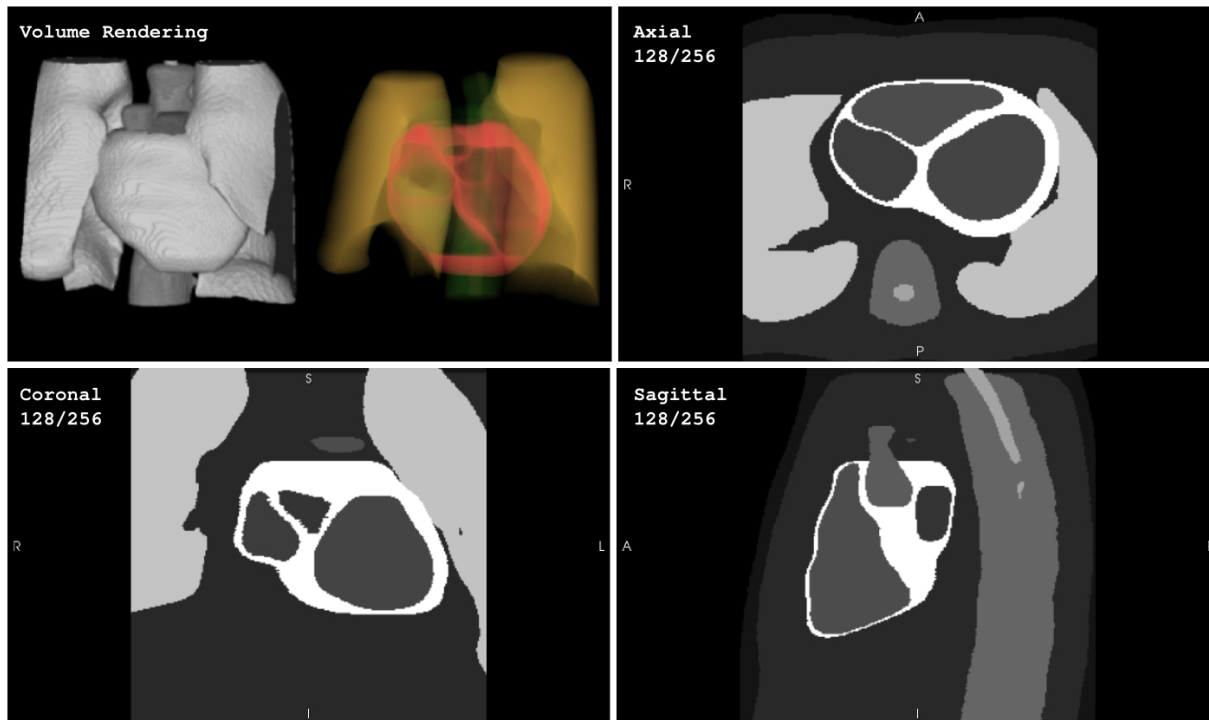
Model **Heart**
Object geometry labelled with matter names and physical values.

Model size 256x256x256

Computing time
(Estimated 1 CPU-Core) **769 days**

VIP for VPH in action

Use Case Scenario – Model 2
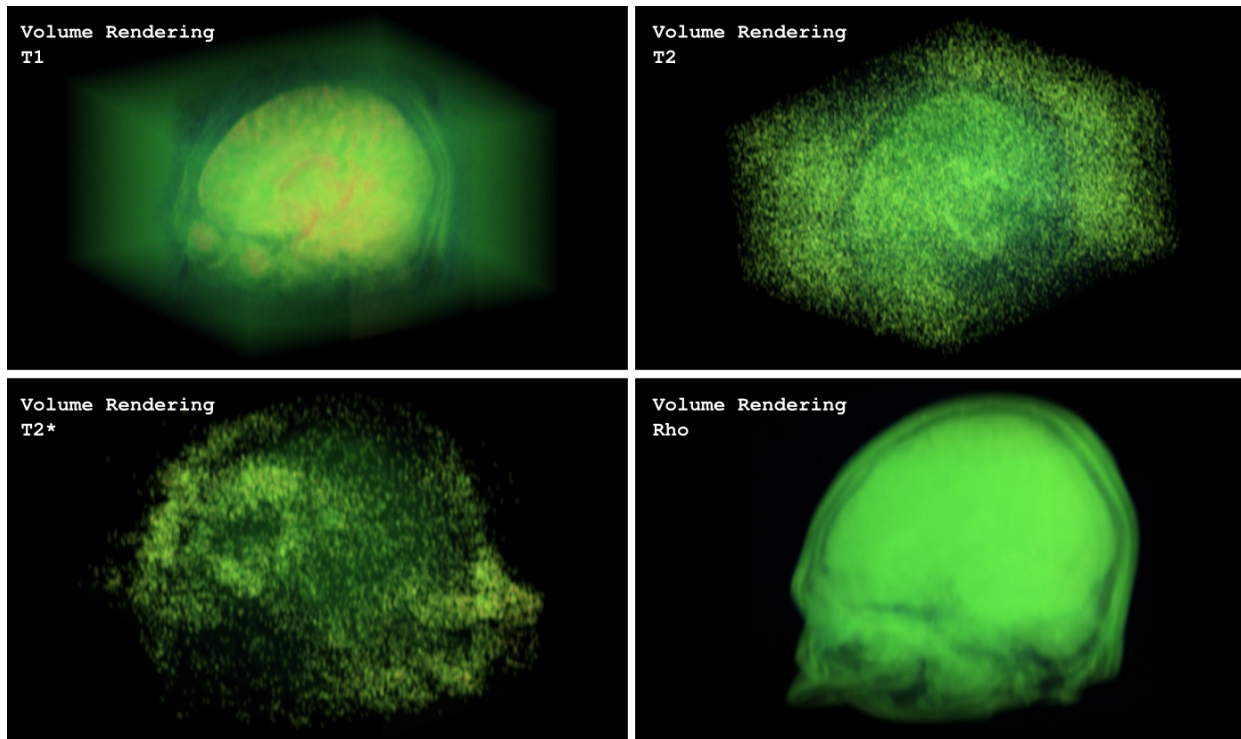
Model **Brain**
Relaxation time map
T1, T2, T2* and proton
density.

Model size 256x256x256

Computing time
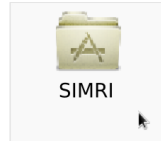(Estimated 1 CPU-Core) **769 days**

VIP for VPH in action

VIP for VPH in action

Use Case Scenario – Results

A 2D MR balanced steady state free pre- cession (bSSFP) sequence at 1.5T was simulated on a cardiac cycle (14 instants) extracted from the ADAM model.
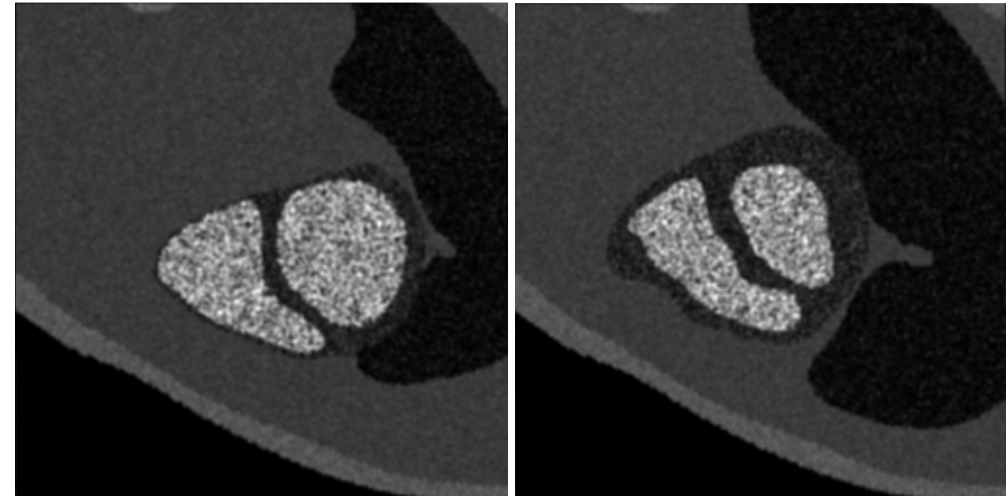
This image was preliminary to preparing a large-scale simulation based on the relaxation time maps model.

Model	**Brain** **256x256x32**
CPU-Cores	1024
Computing time	04h18

Model	**Heart** **14 Instances**
CPU-Cores	64
Computing time	7 min.

Concluding remarks

- A reliable solution for MPI-Based applications is available to the VPH community based on VIP – AHE – PRACE.

- Available in the VPH toolkit.

http://toolkit.vph-noe.eu

Concluding remarks

- The VIP for VPH service empowers users with data and computing resources for:

    - Heavy simulations and heavy Image processing algorithms.

    - Tool for Hands-on learning/training.

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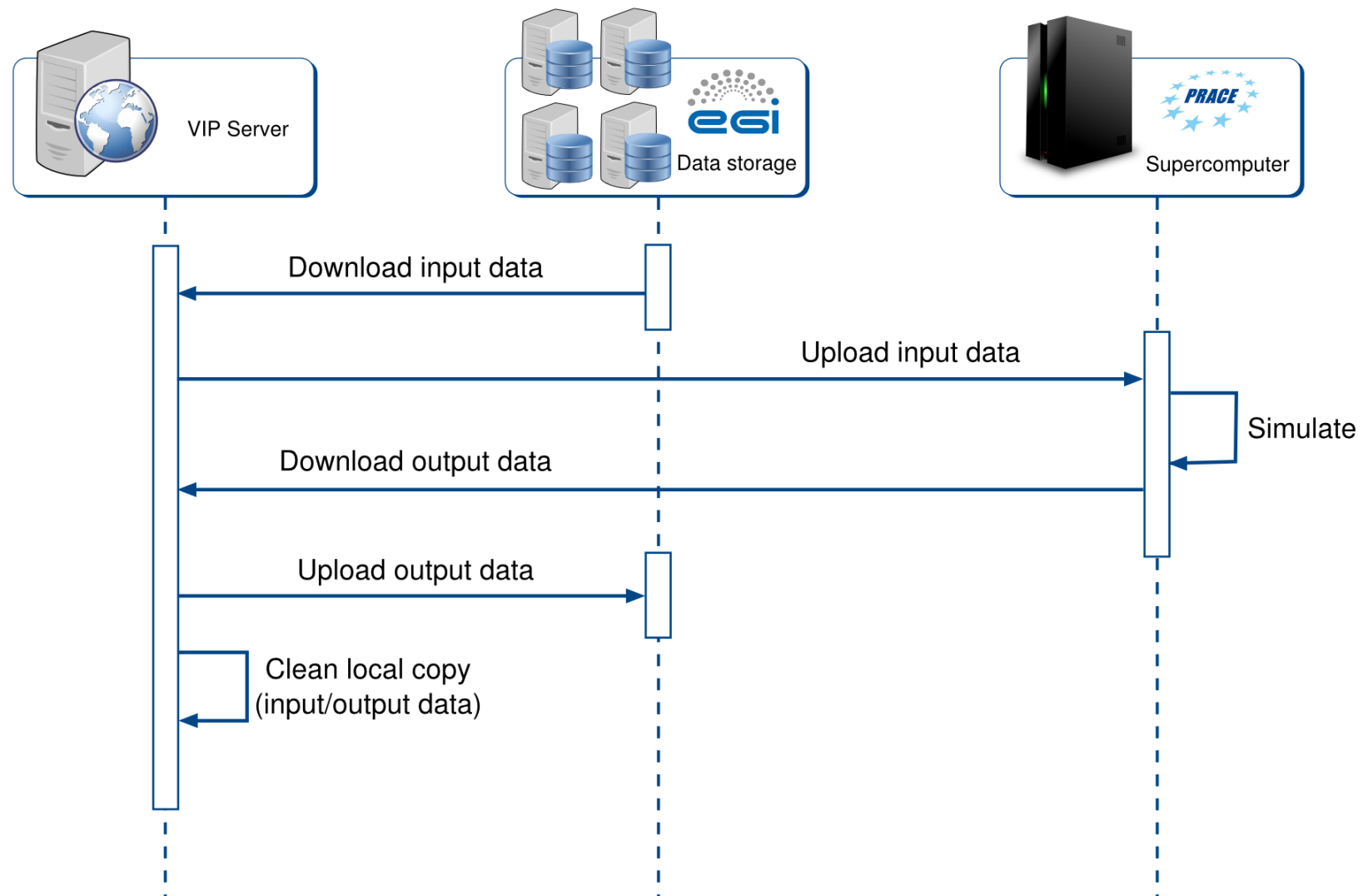
Q & A

Virtual Physiological Human
network of excellence

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Backup slides

Data transfer

- Data transfer from the EGI data storage system to the target processing supercomputer.

PRACE - DECI-8 proposal

- The project has been granted access to a Tier-1 supercomputing provided by the Partnership for Advanced Computing in Europe – PRACE. This includes 1,670,670 standardized PRACE core-hours for MRI simulations.

Execution type	Model size	No. CPU Cores
	256^2	64
Application testing protocol	128^3	128
		256
		512
		1024
Production	256^3	1024

VIP for VPH – Execution types