



Interactive European Grid

Parallelization of IMRT treatments simulations

Lino García Tarrés (speaker)¹

J. C. Mouriño¹, A. Gómez¹, C. Fernández¹

J. Pena², F. Gómez², D. González-Castaño²,

F. J. González-Castaño³, D. A. Rodríguez-Silva³,

M. Pombar⁴

¹Fundación Centro Tecnológico de Supercomputación de Galicia (CESGA), Santiago de Compostela, **Spain**

²Departamento de Física de Partículas, University of Santiago de Compostela, **Spain**

³Departamento de Ingeniería Telemática, University of Vigo, **Spain**

⁴Hospital Clínico Universitario de Santiago, Santiago de Compostela, **Spain**

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What eIMRT is ?

eIMRT means Intensity-Modulated Radiation Therapy.

Consist on a Computer-controlled x-ray accelerator which distributes precise radiation doses to malignant tumors.

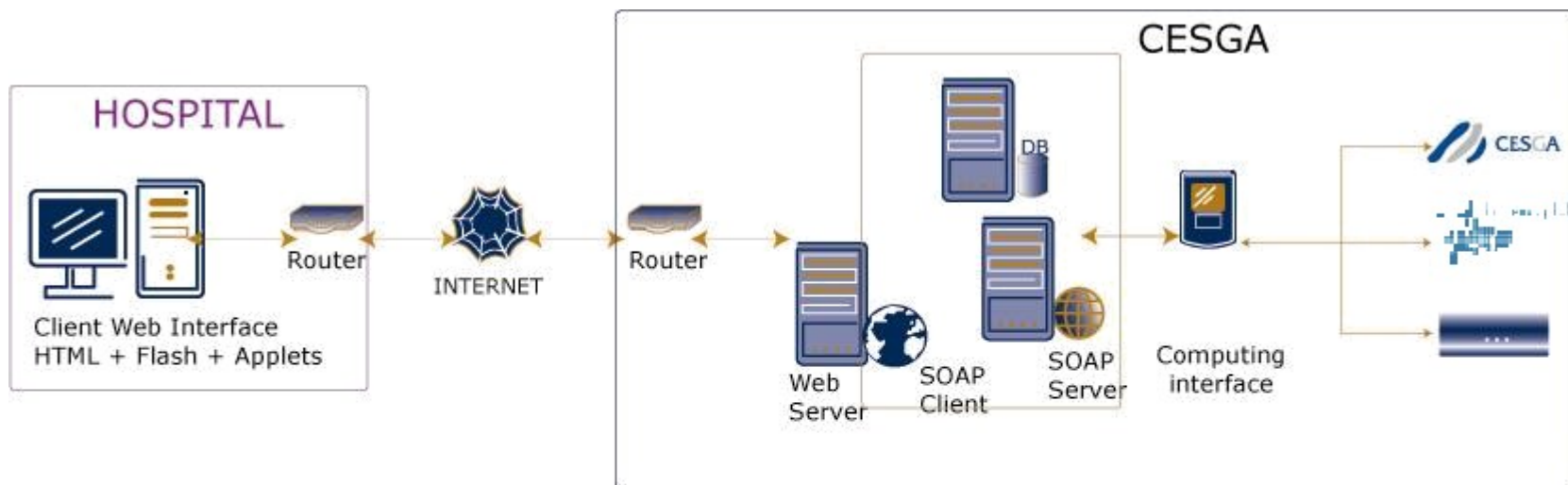
The radiation dose is consistent with the shape of the tumor by:

- ❑ Controlling, or modulating, the radiation beam's intensity.
- ❑ The profile of each radiation beam is shaped using a multileaf collimator (MLC) and a variable number of beams.



- The application main objective is the optimization of radiotherapy plans by **computing the amount of radiation absorbed by the human body organs** for different treatment ray intensities, trajectories and shapes.
- The inteugrid NA3 **activities at CESGA** is now focused on implementing the **parallelization** of the eIMRT **code** in order to reduce its overall execution time. The objective is to spend **less than 60 minutes** for the whole process.

eIMRT Architecture



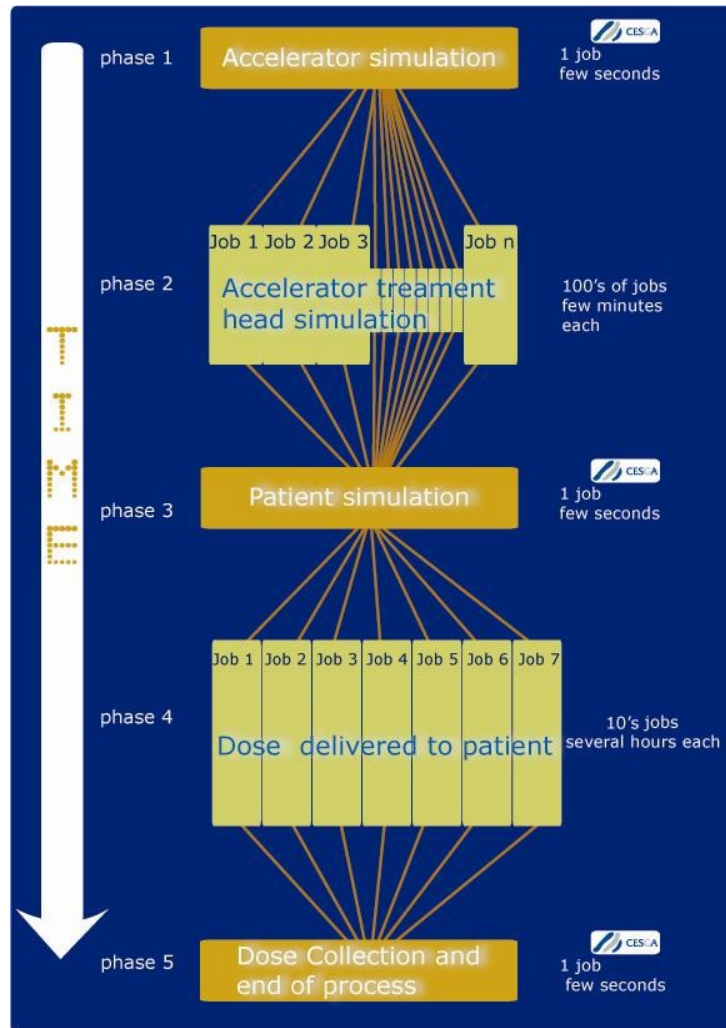
Middleware requirements

- ❑ A typical IMRT dose analysis performs between **30 and 100 short timed jobs of about 15 minutes each one**. The main objective is to not spend more than 60 minutes for the whole process.
- ❑ **Confidentiality** of patient data must be guaranteed.
- ❑ Data transfer velocity: a typical solution consists of 4 trajectories (or shoots) and the correspondent absorbed radiation file is about 1Mb in size. The whole **information** must be **sent in less than a second**.
- ❑ Disk capacity. A typical patient data topology spends about **25Mbytes of disk storage**.
- ❑ The application is developed in **ANSI C using XML version 2.6**
- ❑ The User interface is based on **Java and MATLAB**. Final visualization tool in development.
- ❑ The User interface will be web based and must communicate with computational resources through **web services**.
- ❑ The application has been parallelized using **openMPI**.

eIMRT Optimization phase

- ❑ **Initialization** of patient and medical equipment **simulation data**.
- ❑ **Computation of radiation absorption** by patient body for different ray trajectories. A pool of ray trajectories & absorbed doses is finally available. The most **computationally demanding** phase.
- ❑ **Optimization**. A pool of solutions which meets the Doctor's requirements is presented.
- ❑ The **Radio-Physicist selects the best solution** from the pool.

eIMRT verification phase



- Accelerator simulation.
- Accelerator treatment head simulation.
- Patient simulation.
- Dose delivered to the patient.
- Dose collection and end of process.

Degrees of freedom:

- ❑ Radiation intensity.
- ❑ Collimator shape.
- ❑ Ray direction.
- ❑ Bed position.

Data replication:

Distribution of “subsets of directions” among processors
by using OpenMPI.

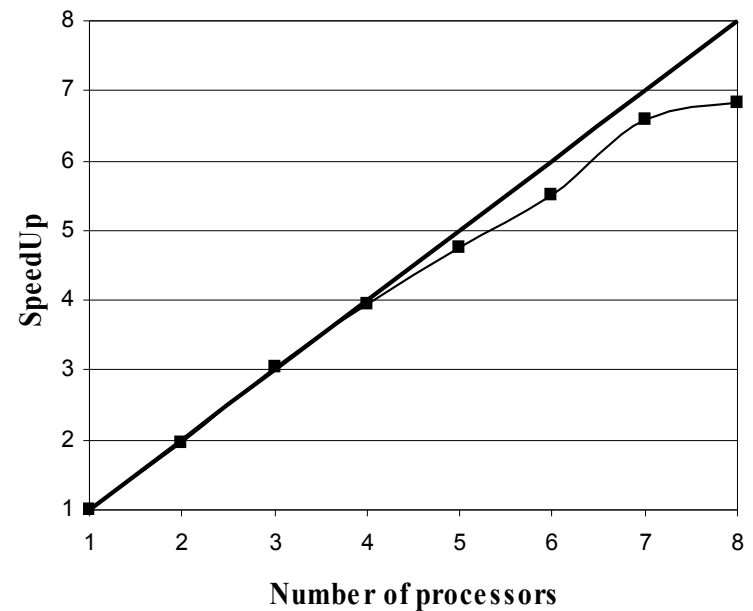
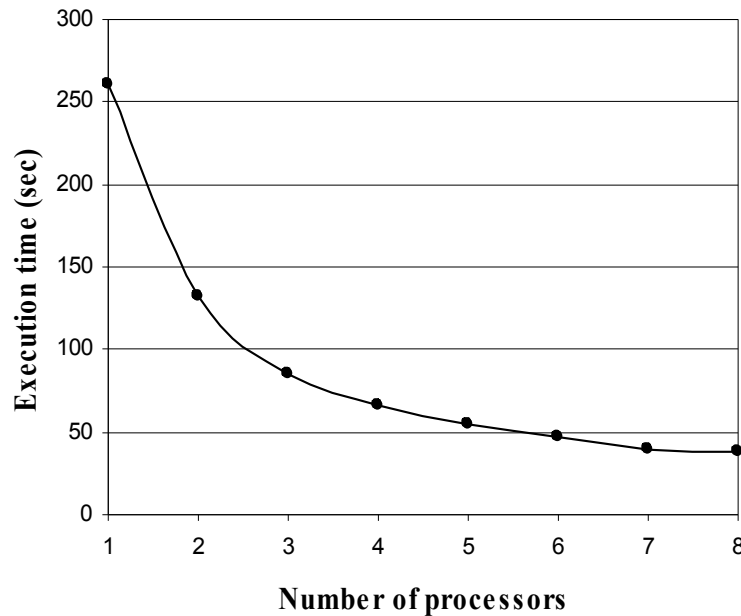


Preliminary Speed-Up results

Where:

$$SpeedUp(p) = \frac{T_1}{T_p}$$

- p is the number of processors.
- T_1 is the execution time of the sequential algorithm.
- T_p is the execution time of the parallel algorithm with p processors.



Drawbacks on initial grid tests

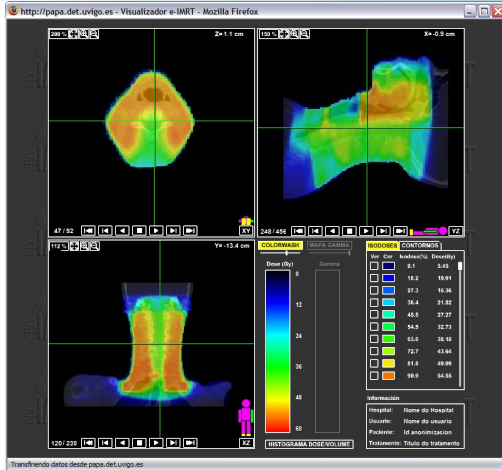
- ❑ **Resource broker** response time is **slow**.
- ❑ **Certificate** proxy **timeout** before job ends.
- ❑ **Confidentiality** of patient data, which must be guaranteed.
- ❑ **The application's user interface** is web based and **must communicate** with computational resources **through web services**.

- ❑ **Validation & porting to different MPI flavours (PACX-MPI).**
- ❑ **Parallelization** of the **Optimization** phase.
- ❑ End-to-end **authorization based on certificates.**
- ❑ **Interactivity.** The user interacts with the simulation in order to visualize the treatment impact on the human body and to select (or reject) the searching path to follow.

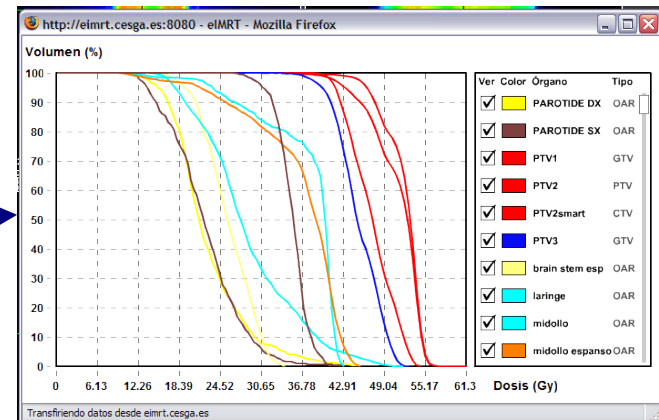
Interactivity demo

<http://eimrt.cesga.es>

Dose colorwash, isodoses and contours



Dose-Volume Histograms



Gamma and Other comparative Maps

