

eIUS: Radiotherapy Final Use Case

In these examples, underlined elements are based either on the original interview data or on feedback sent by the informants in response to draft versions of the use cases. Key *activity types* are highlighted in *italics* and **relevant ICTs** in **bold**.

Use Case 15 – Radiotherapy

Narrative

1. Elaine is a scientist working at a department of medical physics which conducts applied research on radiotherapy, a high energy radiation treatment of cancer, at a hospital in the UK. The calculation of the dose and the verification of the accuracy of this treatment are of particular importance in radiotherapy physics in order to target the tumour in the desired way, not affecting the organs or tissue in (very close) proximity.
2. This morning Elaine has a meeting in her office with Steven, one of her colleagues working in the same research group, who just came back from an international radiotherapy conference in North America. They discuss feedback Steven got on his presentation of **Monte Carlo Treatment Planning (MCTP)** which is the approach they are using and researching intensely in their department and various projects.
3. The advantage of MCTP in contrast to conventional Treatment Planning Systems (TPS) lies in the use of Monte Carlo Simulation software. In a real time computer model it simulates tracking the emitted radiation particles going through the patient's body and depositing their energy thereby collecting data to improve the accuracy of the radiation treatment. Part of Steven's feedback from the conference suggests having a closer look at a new **method and code** used for the simulations.
4. After the meeting Elaine opens her browser and checks the literature on the MEDLINE and PubMed databases regarding recent applications of this **method** and downloads some articles for further reading.
5. Meanwhile Steven works on setting up the next simulation. On the **PC** he opens a kind of digital patient file provided by a medical doctor with information on the indicated treatment including digital CT (Computed Tomography) images stored in the DICOM format. Then he uses the MATLAB software to transfer and code the derived calculations for the radiation dose and to subsequently run the **Monte Carlo Simulation.**
6. The **Monte Carlo Simulation** calculation techniques are more accurate than other methods but at the same time they are computationally quite intensive and a simulation would take days for one patient alone. To treat the patients without delay the results have to be available as quickly as possible. For that reason the research group has taken up a collaborative research project with a UK university's computer science department which provides the know-how on the

implementation and use of distributed computing resources like **clusters** and the **GRID**. This enables running simulations in mere hours than days.

7. Before starting the batch of simulations Steven calls Frank to ask him, if the **web portal** they developed in the project for access and job submission to the insitutes **CONDOR computer cluster** is available again after the upgrade yesterday. Frank is one of the computer science experts who *collaborates closely* with the radiotherapy scientists. He has just completed the installation of the upgrade of the web portal and restarts it on the server, giving Steven a go for the simulations.
8. Steven *accesses the web portal* in his browser, *chooses a preconfigured profile* for the kind of jobs he wants to run through the **CONDOR cluster** and *clicks submit*. Having received a completion message via email he checks the **CONDOR job management system** on the portal the next day and hence the results are ready he *downloads* them onto his PC and attaches the suggested radiation dose and treatment plan.
9. Steven discusses the results with Elaine and then sends out the data via a commercial vendor to the medical doctor who has to approve the treatment plan and dose distribution for her patient. There are no objections and after *careful consideration* the treatment is then put into effect a short time later.
10. A week later Elaine meets with Steven and Frank to discuss a *submission* to the 'Medical Physics' journal, incorporating their recent work in the collaborative project and Elaine's literature review findings on new **methods and codes for Monte Carlo Simulations**.

Relevant ICTs

ICT	Comments
MCTP (Monte Carlo Treatment Planning)	Radiotherapy hardware (CT/MRI scanner; radiotherapy treatment machine) and software system for the planning, calibration, quality assurance and documentation especially incorporating Monte Carlo Simulation in the context of radiotherapy treatment. (also see TPS below)
Treatment Planning System (TPS)	Conventional radiotherapy hardware (CT/MRI scanner; radiotherapy treatment machine) and software system for the planning, calibration, quality assurance, documentation and simulation in the context of radiotherapy treatment.
Monte Carlo Simulations Monte Carlo Treatment Planning	Monte Carlo Simulations are a statistical methods for simulating systems in real-time taking into account randomness by investigating hundreds of thousands of different scenarios, or in the case of radiotherapy

	<p>‘events’ of emitted radiation particles going through the patient’s body. For this reason the method requires vast computational power, i.e. distributed computing. The results are then compiled and used to make decisions and assess risk with the help of statistical probability. As in this case It is often used for uncertainty analysis and optimisation.</p> <p>There are various codes of Monte Carlo Methods (technically a class of computational algorithms), e.g. GEANT or PENELOPE.</p>
MEDLINE ¹ and PubMed ² databases	MEDLINE is an online database for life sciences and biomedical bibliographic information; PubMed is an online portal combining various resources, predominantly a database for life science journals for biomedical articles.
Digital Imaging and Communications in Medicine (DICOM) ³	<p>The DICOM format is the standard for handling information in medical imaging and it includes a network communications protocol and a file format definition.</p> <p>Digital medical images, e.g. Computed Tomography (CT) and Magnetic Resonance (MR) images, are usually stored in this format.</p>
MATLAB	MATLAB is a commercial programme language environment which is used here to code the data to run the Monte Carlo simulations. It is especially suitable for computationally intensive tasks.
Web Portal for Job Submission	In the collaborative project between the departments of medical physics and computer science this web-based portal was developed as a hub for job submission to CONDOR clusters and other distributed GRID resources in the future, data management, a monitoring and notification system, profiles, incorporated web services and an underlying database (in part built on CONDOR functionality). It makes use of portlet technology.
CONDOR ⁴	CONDOR is a high-throughput distributed batch system for computational resources (e.g. here local and secure computer clusters). Jobs

¹ <http://medline.cos.com/>

² <http://www.ncbi.nlm.nih.gov/pubmed/>

³ <http://medical.nema.org/>

⁴ <http://www.cs.wisc.edu/condor/>

	are submitted to CONDOR and the system decides based on policies on processing those based its resources. It provides functionalities like e.g. resource management and monitoring, job management and policies.
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Commentary

Protagonists: This case study narrative is based on the outcomes of a group session with four interviewees, two scientists working in radiotherapy/medical physics and two in a computer science department. All collaborate in a research project which explores the use of distributed computing for Monte Carlo simulations in radiotherapy.

Two simulation phases exist: The calculation of a radiation dose is described in the narrative. Phase 2, verification is aimed at matching the calculations in the simulation with the measurements that are taken under standard conditions. To this end the calibrations from a machine with data from a radiation treatment room are checked and used as simulation data. In this case the simulation is used to verify the calculations.

Another important aim of the project using distributed computing in radiotherapy is developing prototypes for UK facilities in general, i.e. something that other clinical medical physicists in other clinical institutes could use in the future.

The Access Grid at points also was used for collaboration, e.g. for exchange within a PhD project with Spanish colleagues.

Security (patients' security and data confidentiality) is a general concern with highly sensitive medical data and the requirements to exchange such data via networks (or in this case with using the National Grid Service in the future) are immense and so far not quite met in the whole medical domain.

Comments by Informant

Other Editorial Considerations

Element	Usage
Links to direct quotes?	No
Year?	No
Month?	No
Time of day?	No
Location given?	No
Real institutions named?	No
Real journals named?	Yes
Real conferences named?	No