k-Plan: From the Hospital to the Cluster and Back

Marta Jaros[1], Bradley E. Treeby[2] and Jiri Jaros[1]

[1]Faculty of Information Technology, Brno University of Technology, CZ
[2]Biomedical Ultrasound Group, Department of Medical Physics and Biomedical Engineering, University College London, UK

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1 What Is k-Plan?

k-Plan, tailored for transcranial ultrasound stimulation (TUS) techniques, serves as a **sophisticated modeling tool for TUS procedure planning**. Its user-friendly interface facilitates the selection of an ultrasound device, positioning via a template or medical image, and customization of sonication parameters.

With a seamless workflow, k-Plan enables high-resolution calculations for the ultrasound field and temperature within the skull and brain, all effortlessly computed in the cloud or on an HPC cluster with just one click. **No expertise in numerical modeling or high-performance computing is necessary.**

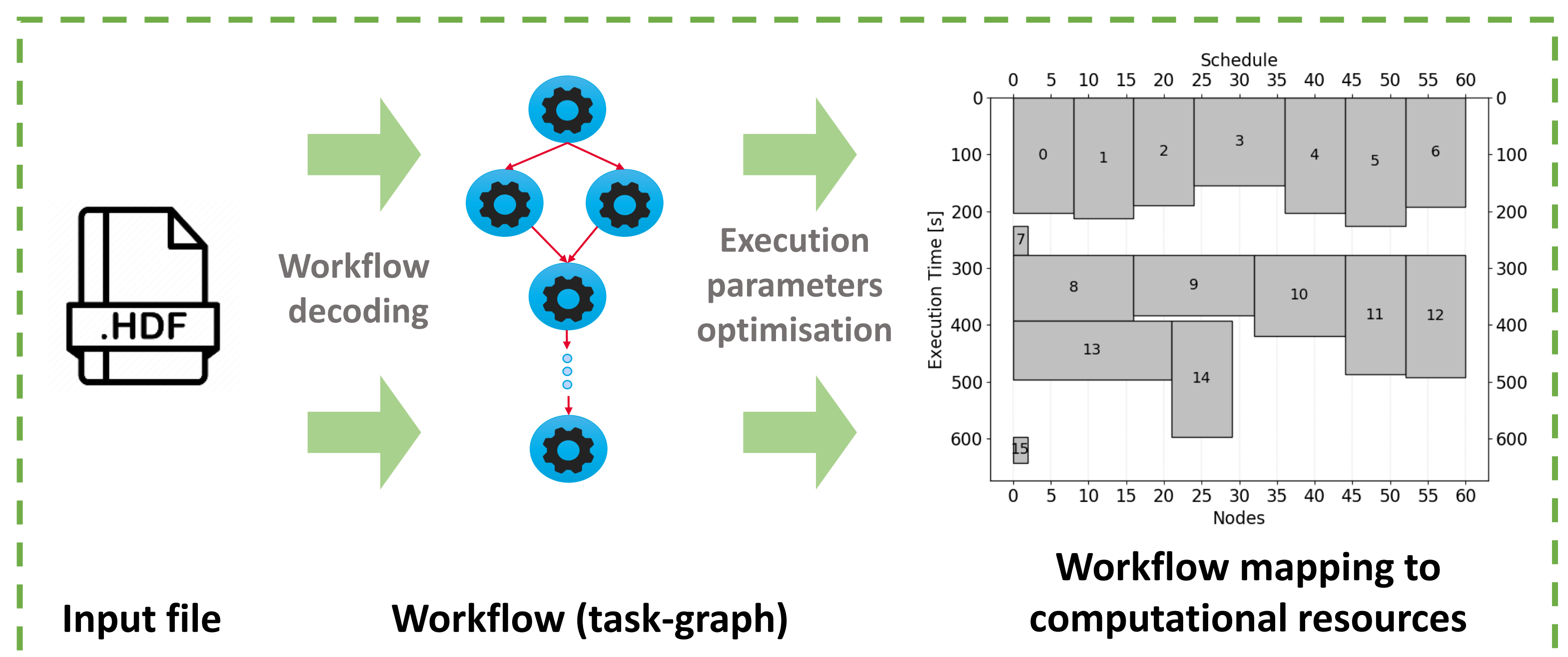**k-Plan system**
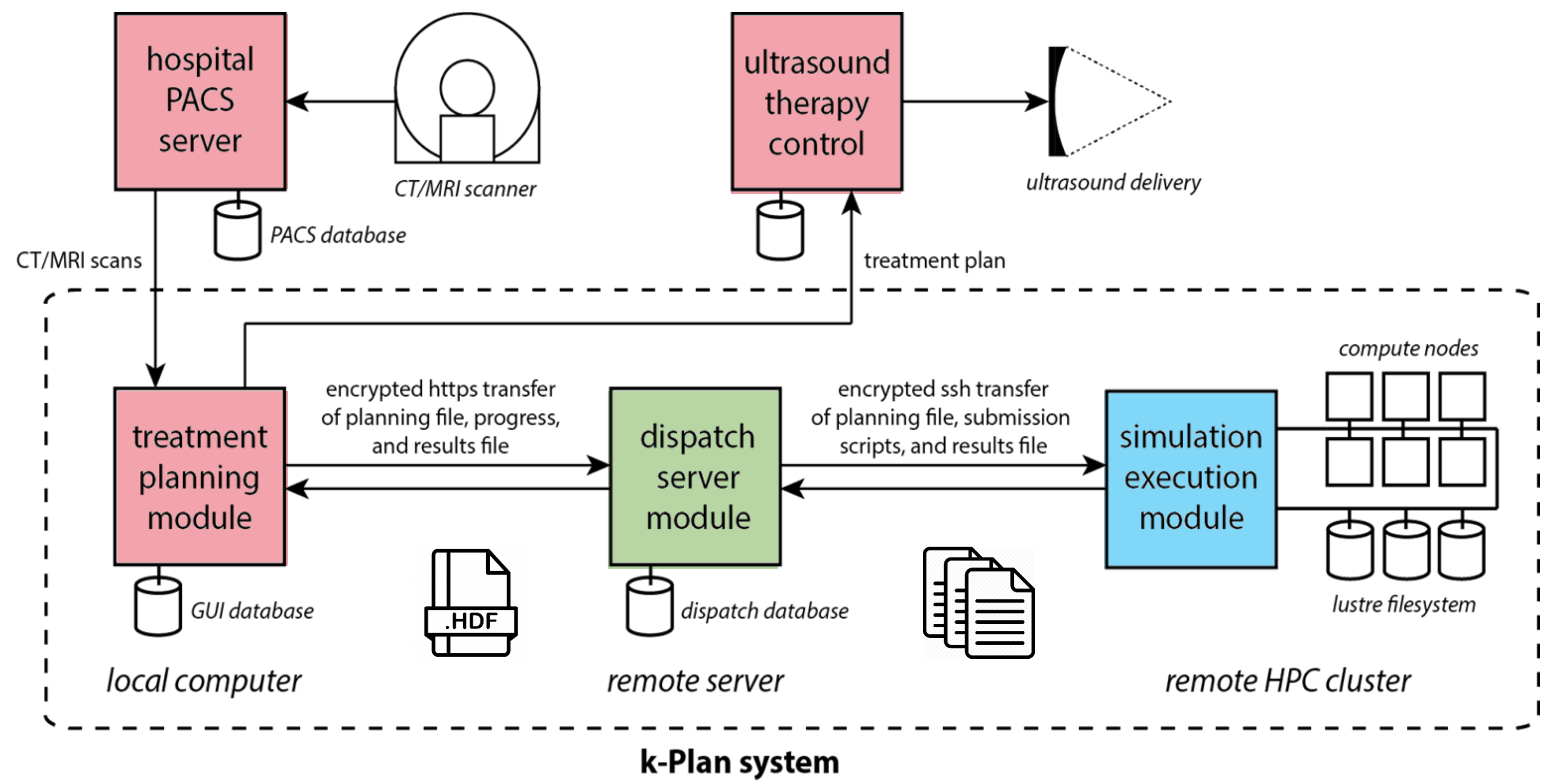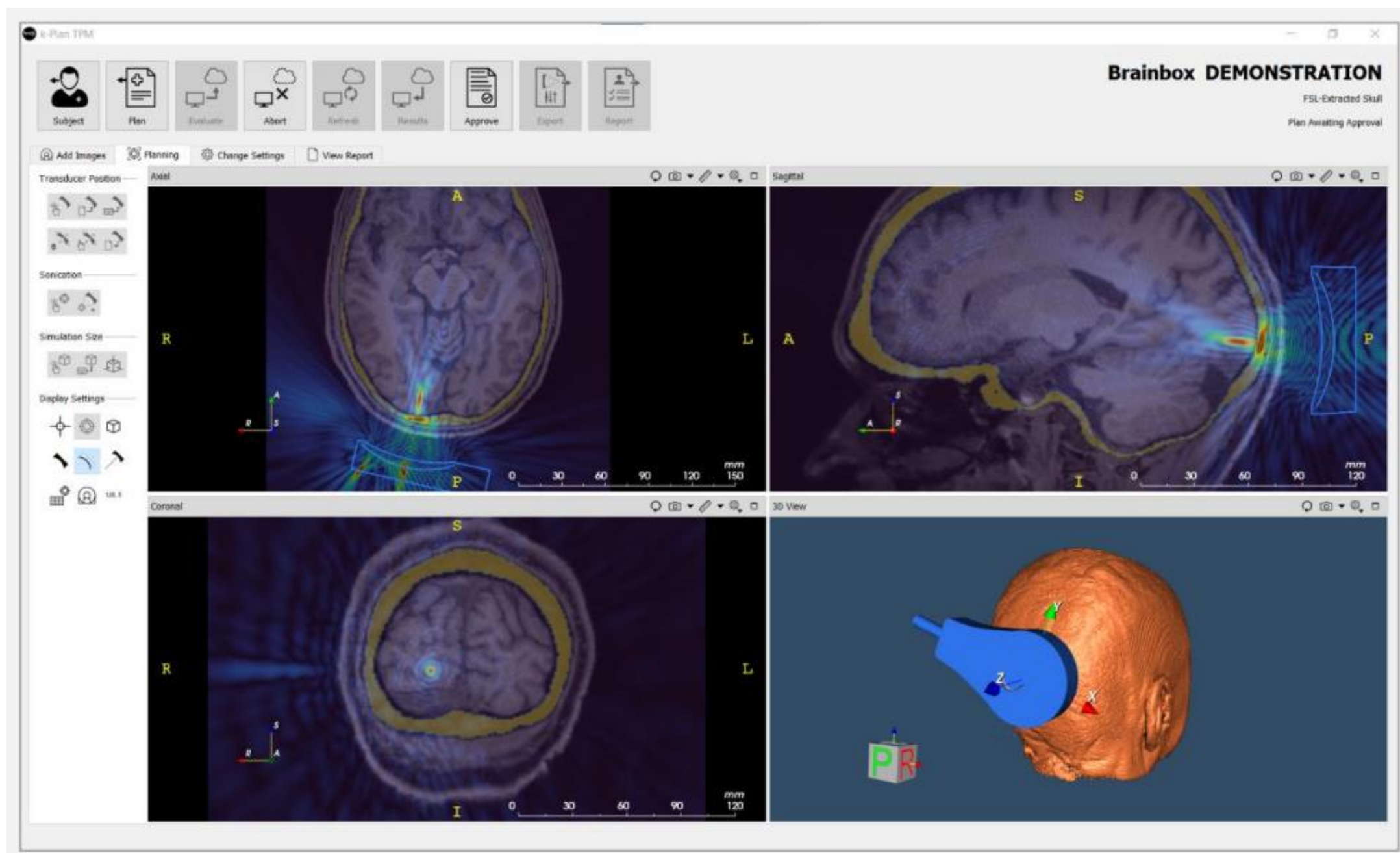
2 Intelligent Compute Engine

k-Plan's smart computing engine **automates planning simulations** for transcranial ultrasound procedures. It seamlessly maps CT skull images to material properties, creates an accurate transducer model using geometric and calibration data, and configures optimal numerical and computational parameters. The outputs are automatically processed to present ultrasound field and brain temperature information, along with calculated exposure parameters.

3 State-of-the-Art Simulation Tool

Behind the scenes, k-Plan runs simulations using **k-Wave**, a state-of-the-art simulation tool that is widely used across academia and industry to study **acoustic wave propagation**. It uses an **experimentally-validated full-wave acoustic model** to calculate how ultrasound waves travel from a transducer through the skull and into the brain. This is coupled with **a model of heat diffusion** and **perfusion** to calculate temperature rise and thermal dose.
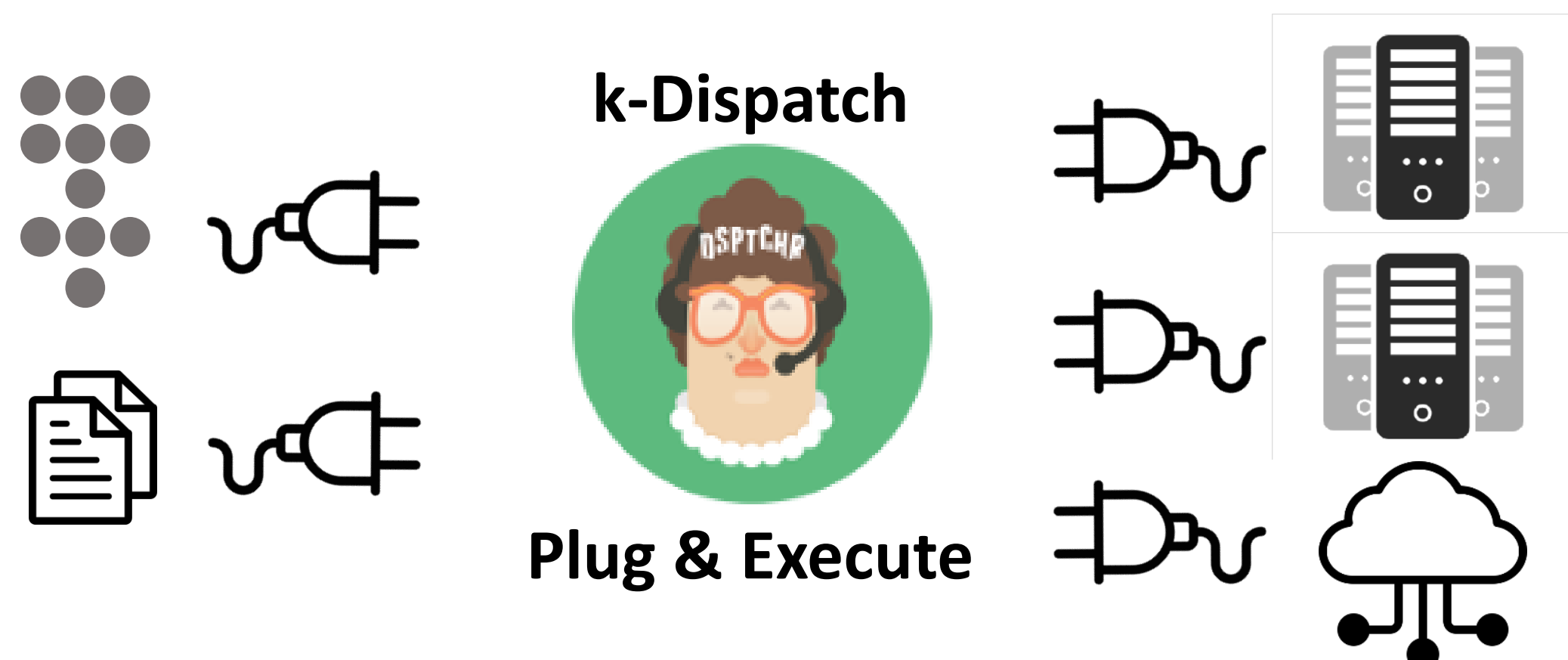
4 Cloud-based Simulations Planning

k-Plan allows access to high-performance computing resources to run high-resolution planning simulations with a single click. Its straightforward installation and intuitive workflow enable users to initiate simulations within minutes, without the need for extra resources or accounts. The automated dispatch server, k-Dispatch, **efficiently allocates computing resources** and **minimises the time between planning and results**. The plan browser automatically updates and displays the status of ongoing simulations.

Workflow mapping to computational resources

5 Workflow Integration

k-Plan integrates into standard **neurostimulation workflows**, including importing and exporting transducer positions for use with **neuronavigation systems** and **exporting plan reports**.

6 Advanced Web Portal

k-Plan's web portal provides a **complete snapshot of your account**, including current cloud computing **allocations**, and **usage history**. Self-service options allow administrative users to add or remove accounts associated with the same software license and modify user privileges.

7 k-Dispatch's Plug & Execute Design

k-Dispatch implements easily extendable design **to add new computational workflows** (a task graph defining task types and dependencies), **support new computing facilities** and **decode new input data**.

8 Conclusions

k-Plan is a complex tool covering **medical modelling tool** and k-Dispatch, a **tool for offloading and managing remote executions** together with **accounting, reporting, and fault tolerance**. The fundamental goal of k-Plan is bringing HPC and cloud technologies to medical environment in a user-friendly way, allow putting stress on either minimal execution time or cost and develop scalable software.

9 Current and Future Work

Next steps in the development are to
(1) **include logs** to monitor computation progress,
(2) **include advanced machine learning techniques** to improve execution planning using the performance database including tens of thousands of records,
(3) **get** information about current remote facility **utilization**.

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k-Wave
A MATLAB toolbox for the time-domain simulation of acoustic wave fields

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