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Interactive European Grid

CT Brain Perfusion Studies

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Outline

- Motivation
- Infarct location
- Perfusion and hemodynamical maps
- Int.eu.grid integration
- Future Work

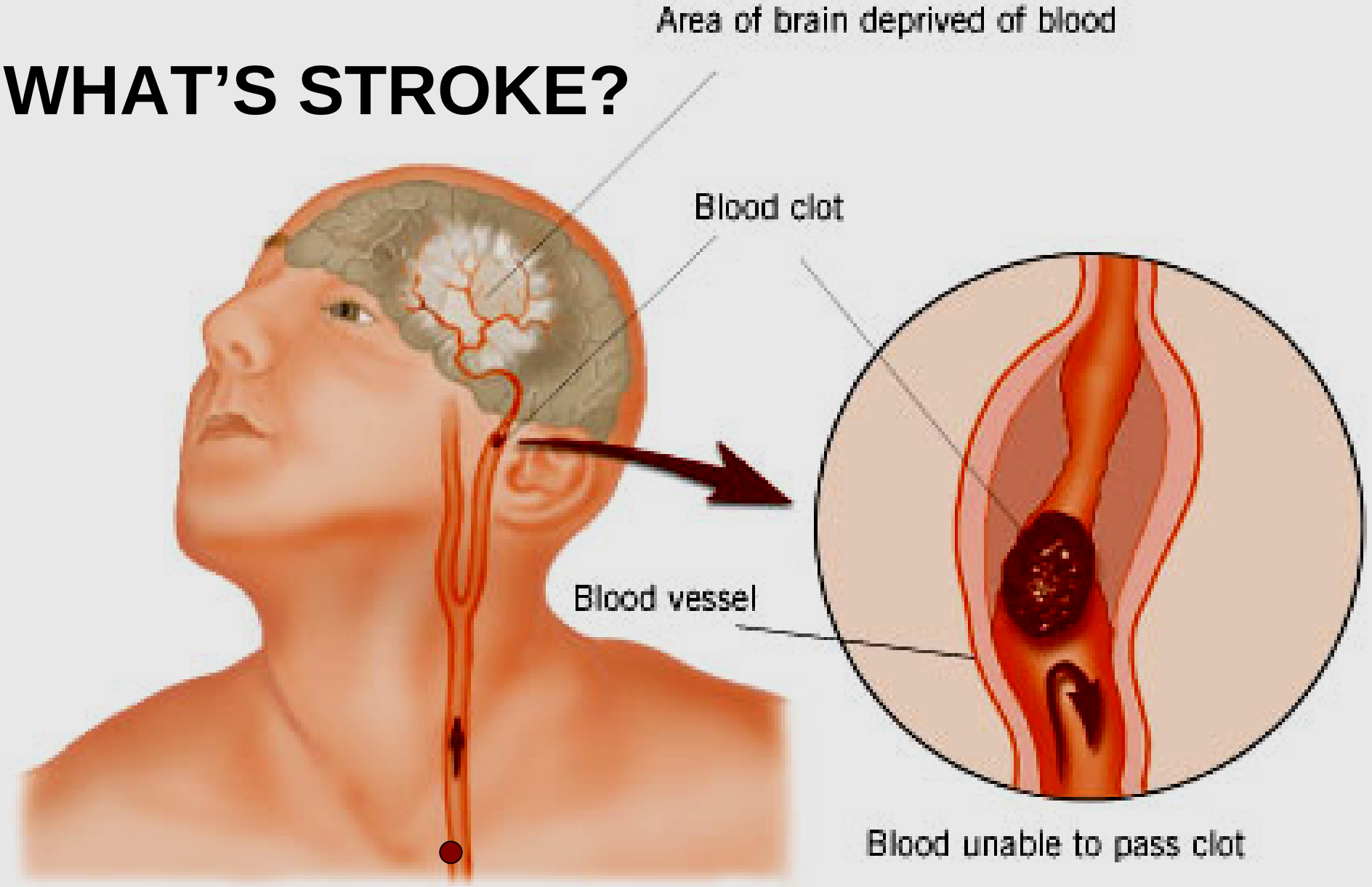
Introduction

- Collaboration between IFCA (CSIC-UC) and Hospital Universitario Marqués de Valdecilla at Santander (HUMV) radiologists.
  - Previous collaboration
- Development of a tool for assisted diagnosis for brain stroke using hemodynamic parameters maps
- Vendor independent parameters calculation testing several methods
- Integration in int.eu.grid

Brain Stroke

- Brain stroke is one of the most important death and disability causes in the EU and USA.
- Currently available treatments could help to reduce the extension of the problem
  - CT Perfusion techniques can help using the acquired images to generate brain maps showing relevant hemodynamical parameters:
    - MTT Mean Transition Time
    - BV Blood Volume
    - BF Blood Flow
  - But need accurate identification of the ischemic lession
- Other relevant information for diagnosis is needed: like angiography

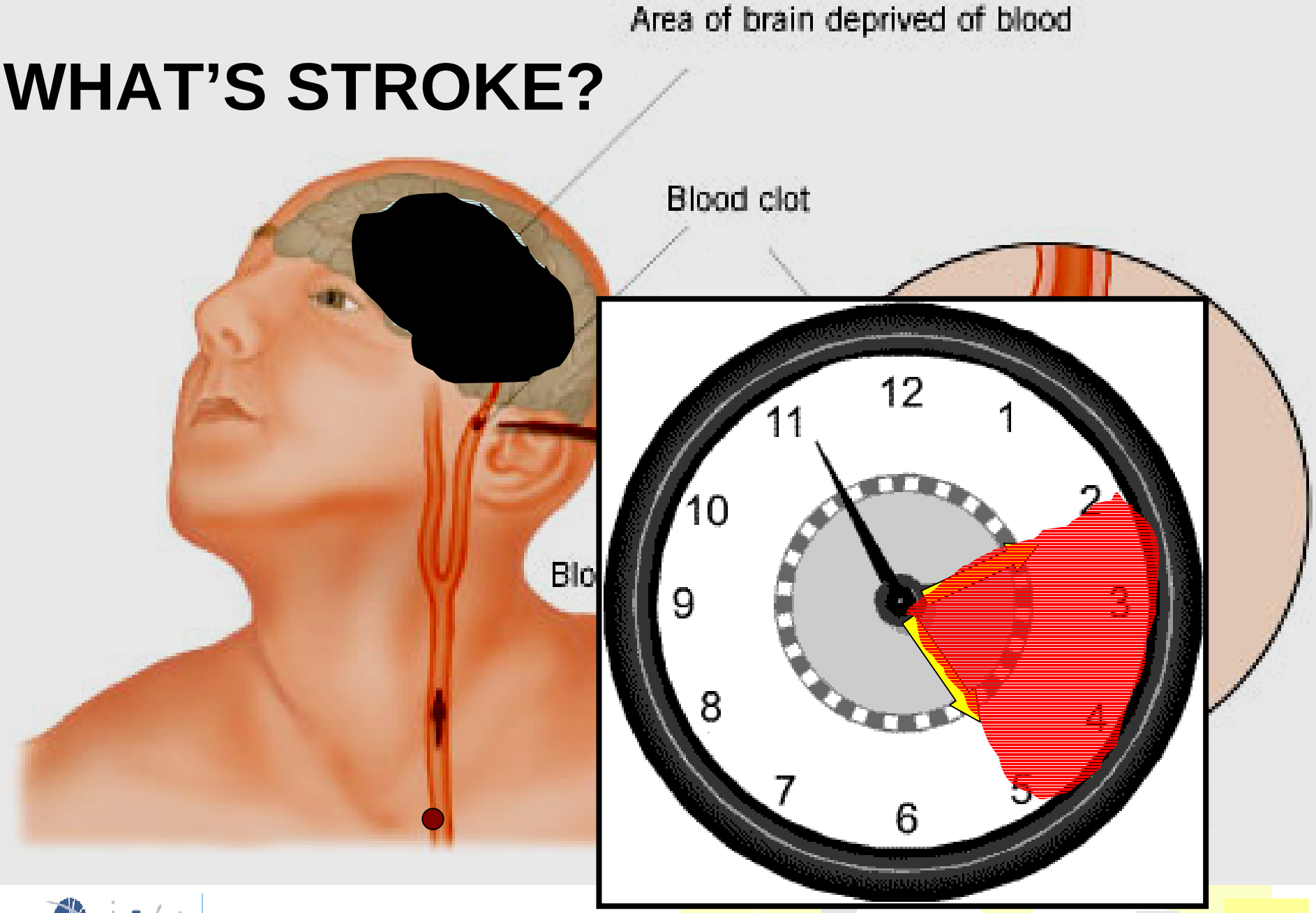
WHAT'S STROKE?

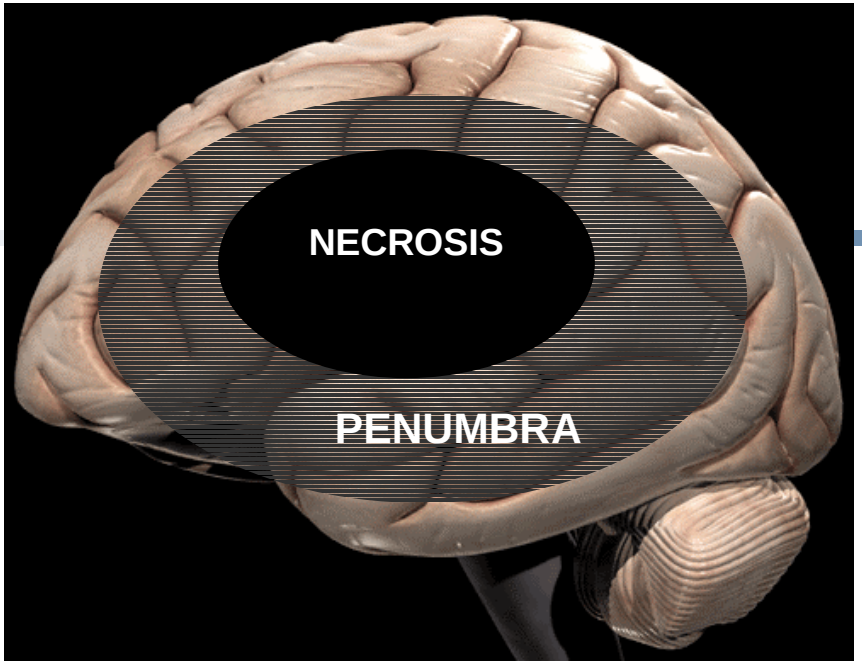


STROKE

- One million strokes occurring per year in the European Union.
- NINDS trial demonstrated usefulness of thrombolytic treatment of stroke in selected patients rescuing the ischemic penumbra.
- Thrombolytic treatment has an associated risk of cerebral hemorrhage up to 20%.

WHAT'S STROKE?





- Core: part of the ischemic region that is irreversibly injured

- Penumbra: area of the brain underperfused and in danger of infarcting.

STROKE

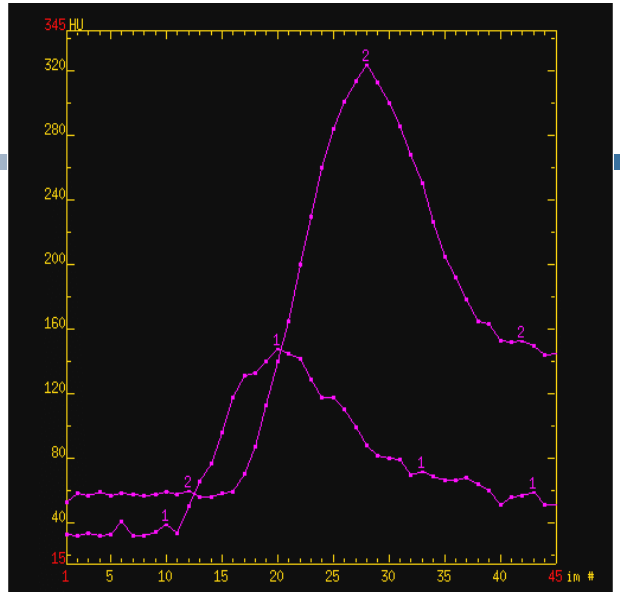
- **CT perfusion** plays a major role by demonstrating salvageable brain tissue and extension of cerebral core infarction.

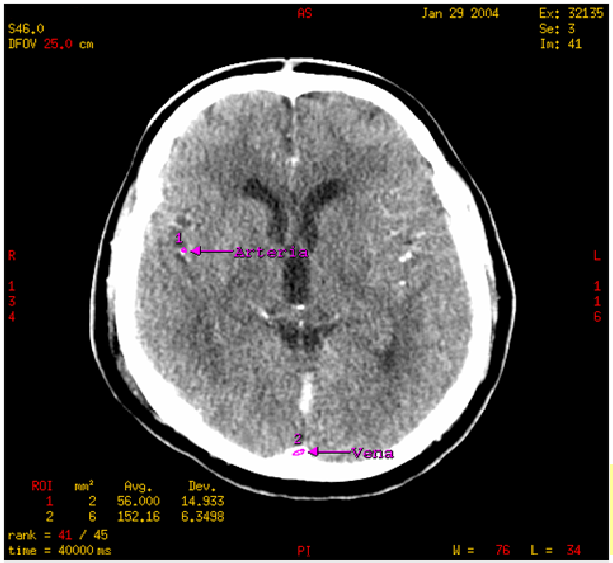
- And… WHAT'S CT PERFUSION??


R
1
4
0
L
1
1
0
rank = 45 / 45
time = 44000 ms
PI
W = 76 L = 32

ANALYSIS

- Attenuation proportional to blood (= contrast) in brain tissue.
- Time attenuation curve of reference:
  - -artery (ACA, MCA)
  - -vein



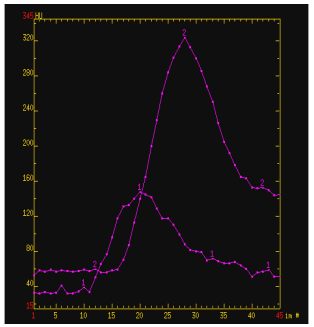


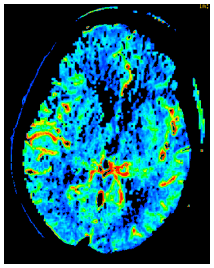
Deconvolution (MTT)

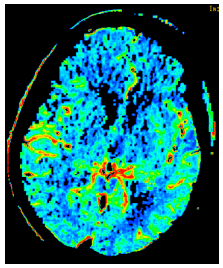
Parametric maps

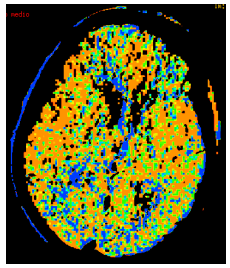
CBV = AUC pixel parench/ AUC pixel artery

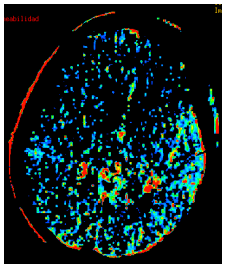
CBF= **CBV** / **MTT**







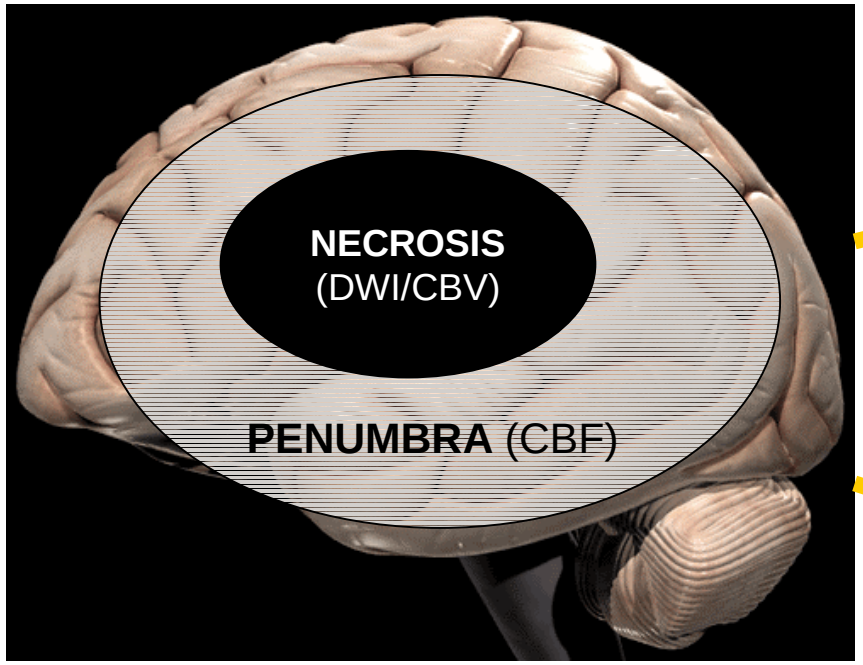


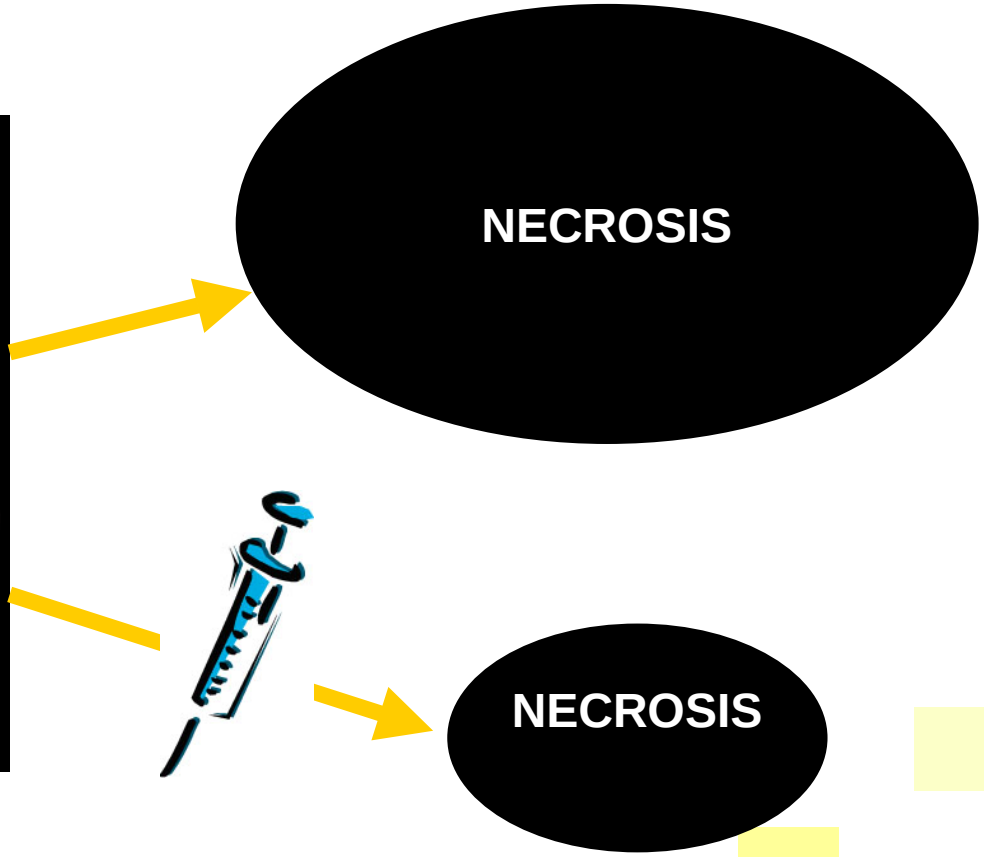


MAIN CLINICAL APPLICATIONS

- **Vascular pathology**
  - ***- Acute ischemic stroke***
  - - Chronic ischemia
  - - Vasoespasm
- Brain tumours

¿salvageable cerebral tissue??





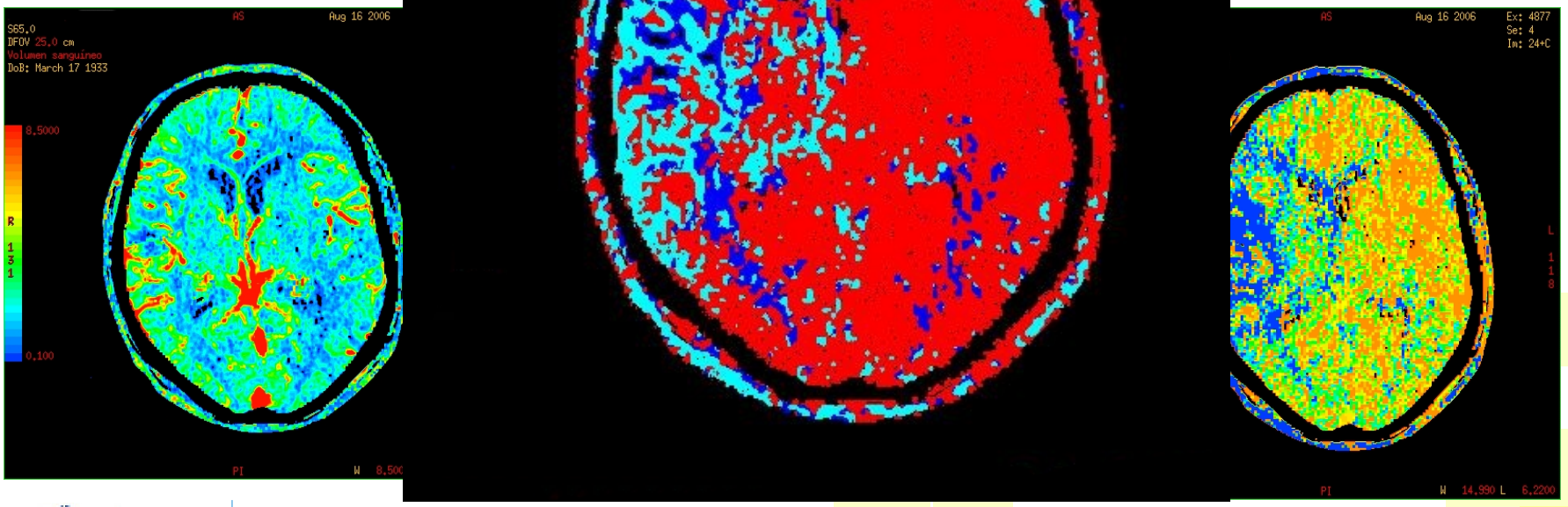
Infarct location application

- Using the cerebral blood flow and the mean transit time generate a brain map showing:
  - The infarct core
  - The ischemic penumbra
- Implemented in Java (ij library for the images)
  - Using input from GE Perfusion application
  - Will use also our maps when finished
- The program fed with the parameter maps automatically calculates an output map
  - The medic can change the criteria
  - Also can define a good tissue region to use as reference

Infarct location

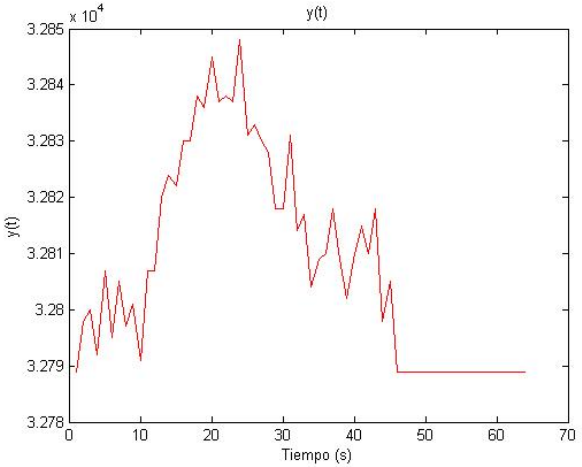
- Now a java standalone GUI application
- It is being p… the Migrating Desktop
  - Would be … n

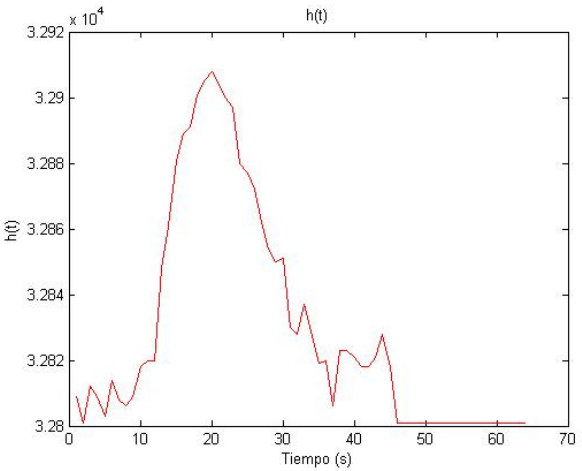
Blood Volume … an Transit Time



CT Perfusion

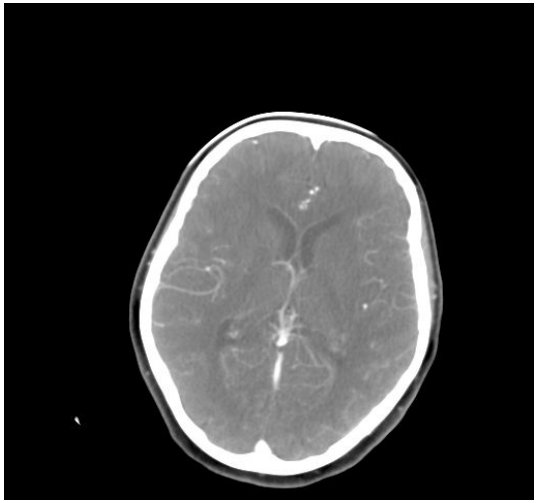
- For DCE (Dynamic Contrast Enhancement) imaging using CT (aka CT Perfusion) a sequence of images (45) at the same location are taken in a given interval.
  - Concertation Time Curves
- The objective is to get the three parameters that are related by the central volume principle
  - This is done voxel by voxel





CT Perfusion Application

- Input: (4*) 45 CT brain images in DICOM format
  - Using as reference an artery and a vein three parameters are computed for each pixel:
    - blood flow (CBF),
    - blood volume (CBV) and
    - mean transition time (MTT).
- Prototype in Matlab
  - Using RegTools Toolbox by P.C. Hansen
- Now implementing the algorithms in
  - ANSI C
  - Java



Deconvolution Problem

$$C_{tiss}(t) = F\int_0^t C_{art}(t)R(t-\tau)d\tau$$

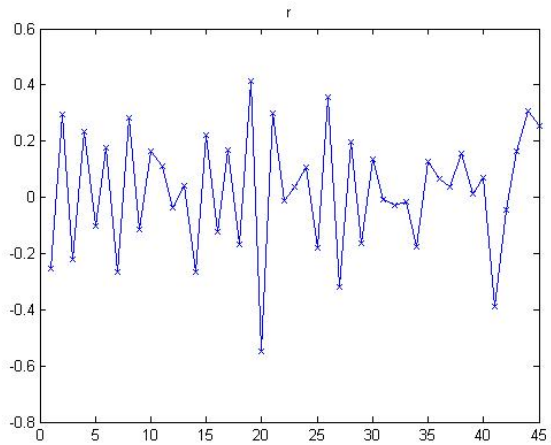
$$C_{tiss}(t) = F\left[C_{art}(t) * R(t)\right]$$

- We want to obtain F and R(t)
- C_{tiss} and C_{art} are the tissue and artery concentrations
- R(t) is the tissue residue function and it is used to calculate the MTT
- Numerical deconvolution process is very sensitive to noise in the measured data
  - Inherently ill-conditioned problem

If using Fourier Transform

$$C_{tiss}(w) = C_{art}(w)R(w)$$

$$R(w) = C_{tiss}(w) / C_{art}(w)$$



Singular Value Decomposition

- Discretize the convolution integral equation
  - System of linear equations
- A is a nxn matriz and x and b are vectors
- Singular Value Decomposition (SVD)

$$A \cdot x = b$$

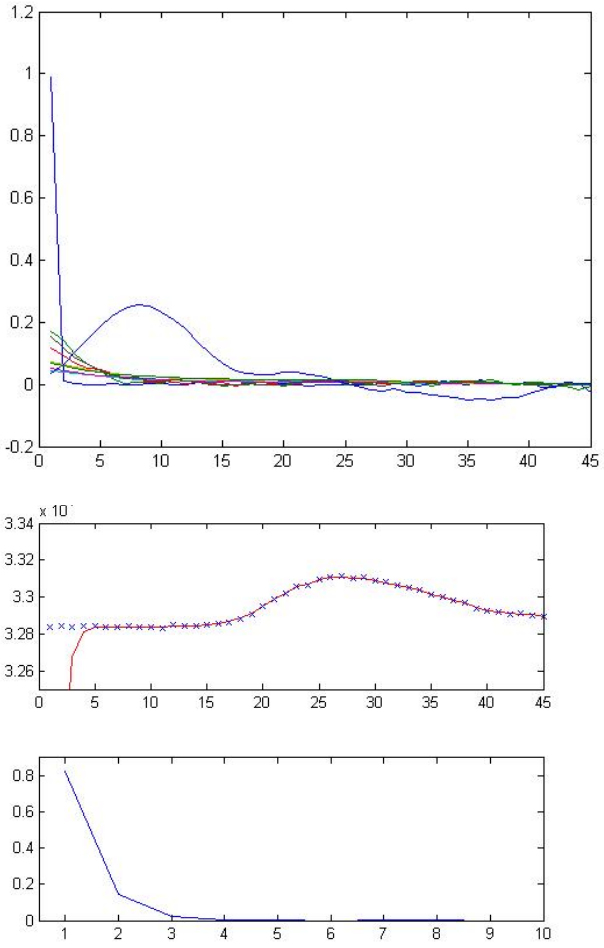
$$x_i = F \cdot R(t_i)$$

$$A = U \cdot S \cdot V^T = \sum_{i=1}^{n} u_i s_i v_i^T$$

$$s_1 \geq s_2 \geq \ldots \geq s_n \geq 0$$

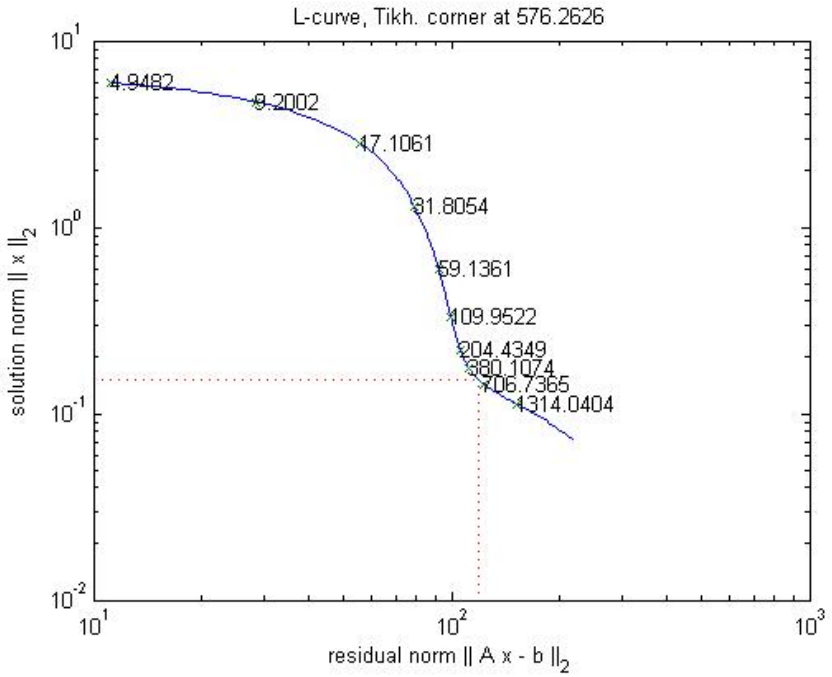
Regularization Methods

- TSVD
  - Singular Value Decomposition (SVD)
    - Threshold or truncation index
    - The smaller singular values are eliminated
    - Limits the effects of noise
  - C implementation using SVDLibC
  - Java using JAMA
- Tikhonov Regularization
  - Prototype in Matlab
  - Java using JAMA



Selection of the regularization parameter

- Picard plots to estimate
- Currently using the L-Curve method



Interactive European Grid Project

Project acronym int.eu.grid

Contract number 031857

Instrument I3

Duration 2 years may ´06- april ´08

Interactive: because researchers need answers in seconds, not in hours.

Grid: easy, intuitive, transparent BUT distributed, powerful, open.

For e-Science: Collaboration.

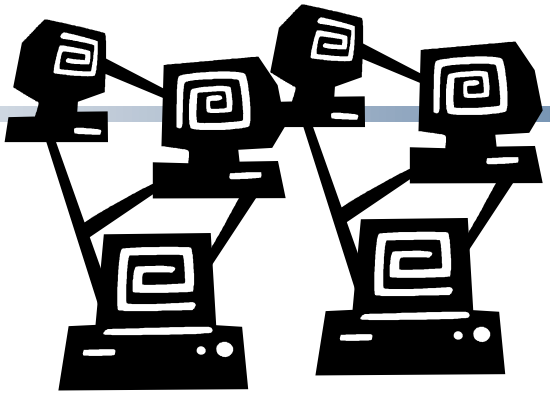
"providing transparently the researcher's desktop with the power of a supercomputer, using distributed resources"

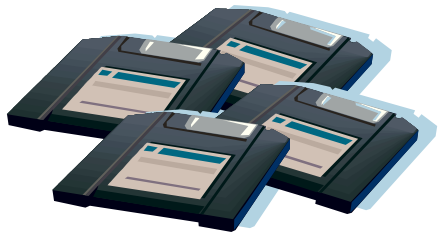
http://www.interactive-grid.eu

Coordinator: CSIC, Jesús Marco, IFCA, Santander, SPAIN [marco@ifca.unican.es]

CSIC-IFCA Coord - Spain	LIP Portugal	PSNC Poland	FIK Germany	UAB Spain	CYFRONET Poland	GUP Austria	TCD Ireland	CESGA Spain	II SAS Slovakia	ICM Poland	BIFI Spain	HLRS Germany

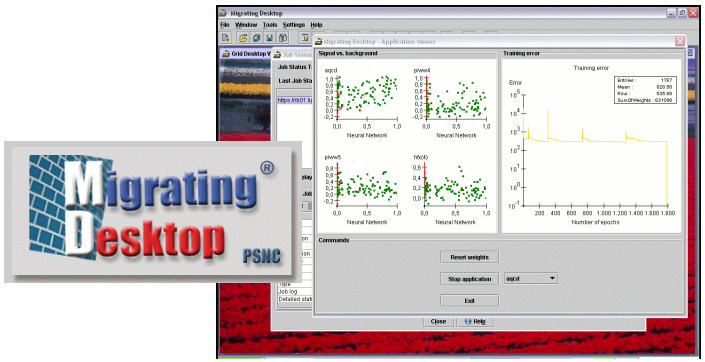
Project Vision





- Distributed Parallel (MPI) Interactive Computing and Storage at the Tera level

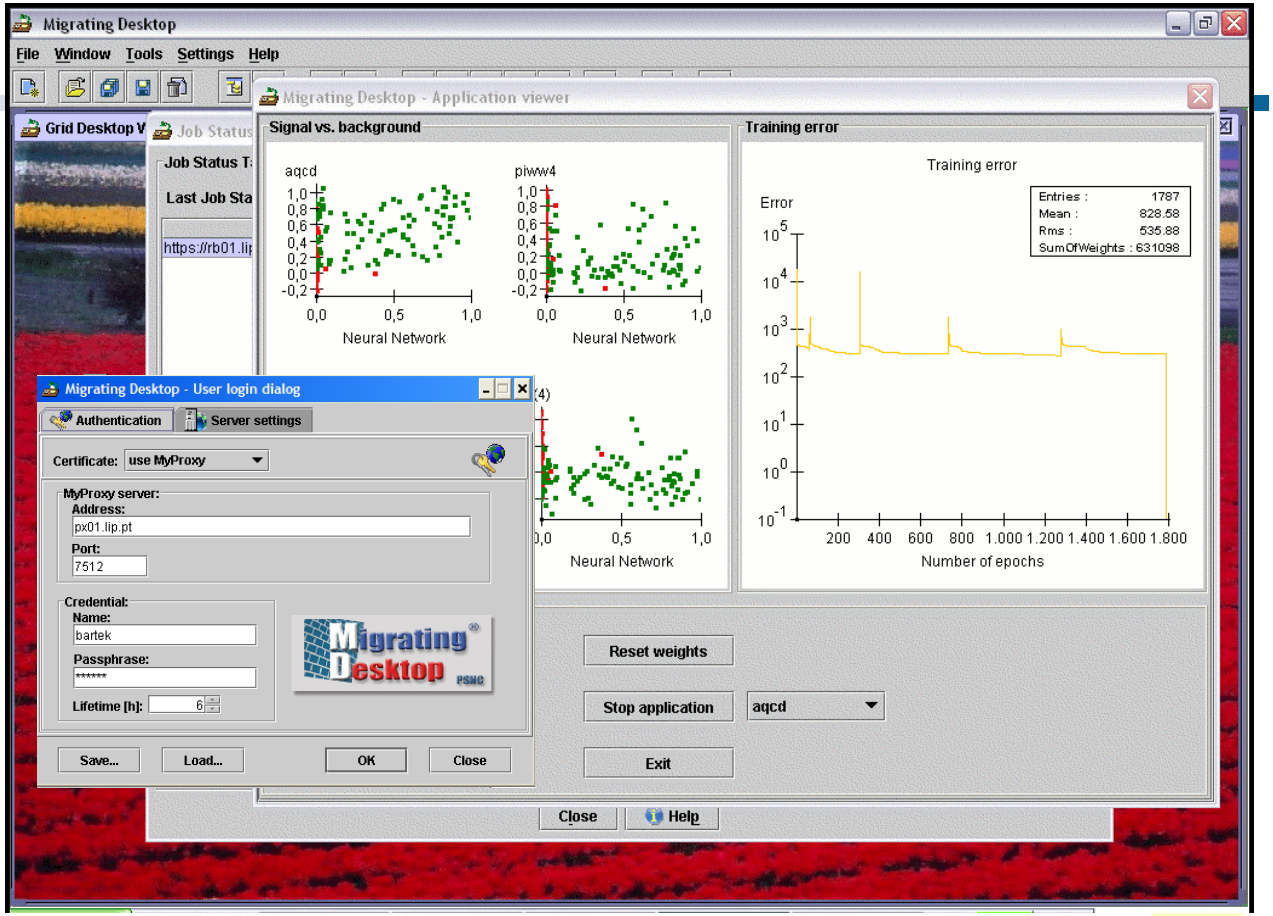
- User Friendly Access through a Grid Interactive Desktop with powerful visualization and real simulation steering in real time



- Supporting Virtual Organizations at all levels: setup, collaborative environment, grid enhancement of applications, execution and monitoring tools.

Migrating Desktop

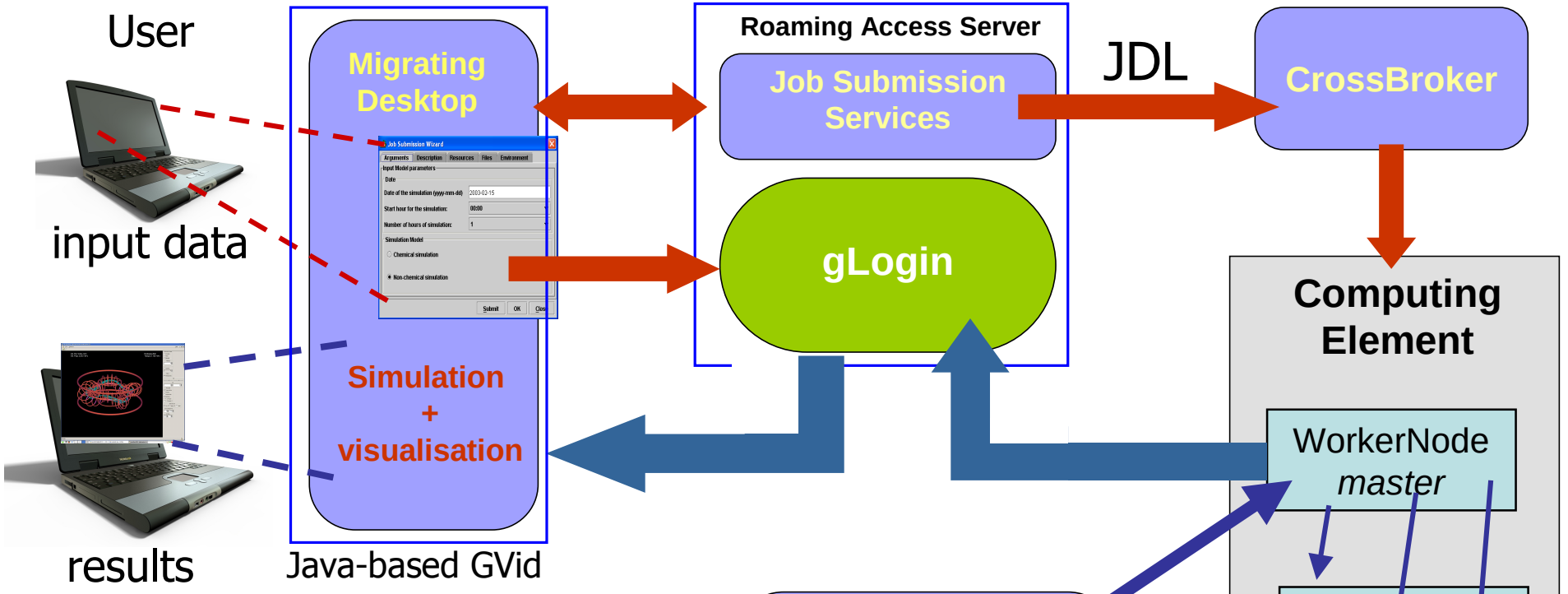
- Single sign-on / authorisation
- Platform independent
- Batch jobs
- MPI jobs
- Running interactive applications using java plugins or VNC
- Monitoring grid applications
- Flexible Application framework
- User profile management
- Easy application add on
- Local and grid file management



Desktop tools:

- Job Wizard
- Job Monitor
- Application Container and Plugin
- GridFTP Commander
- User Profile Manager
- Private Storage Management
- VNC/SSH console

Interactivity



Integration in int.eu.grid

- The TSVD is already running in int.eu.grid
  - Working on Tikhonov regularization
- The infarct location Java application would be included in a MD visualization plugin that:
  - Use DICOM images already at int.eu.grid SEs or register new ones (with anonymization)
  - Would run the brain parameters map creation application using TSVD or Tikhonov
  - Using them would create the core and penumbra map.

Other Future Work

- Implementing alternative techniques for getting the perfusion and hemodynamic parameters:
  - Frequencies filtering
  - Parametrical approaches
  - Bayesian
- Comparing all these techniques with simulated and real data
  - Using Monte Carlo simulations to check the methods robustness against different levels of SNR
- Adapting the application for other medical uses of CT perfusion:
  - Brain tumors