

# **Overview of the GEMSS Project**

11.3.04

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# GEMSS: GRID-enabled Medical Simulation Services

EC funded FP5 IST project: IST-2001-37153

<http://www.gemss.de>

Project Duration: 30 months,

Commencement: 1.9.2002

Grid middleware initiative within medical application setting.

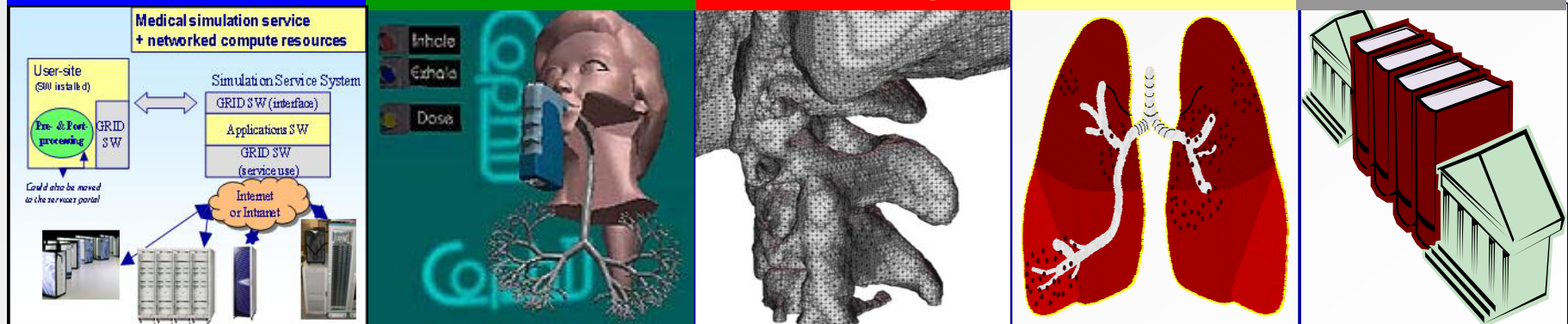
Grid  
Software  
/solutions

Simulation  
/Imaging  
Software

Bio-  
numeric  
modelling

Medical  
Expertise

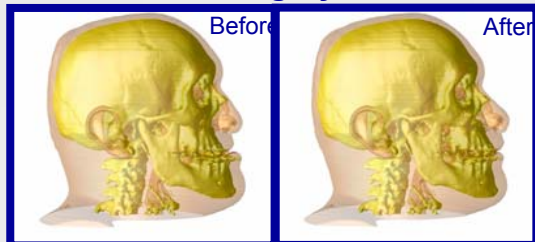
Legal  
Aspects



Consortium:

10 partners from industry & academia including University clinics;  
NEC Europe Ltd, MPI Leipzig, ISS Vienna, CFX Ltd., CRID FUNDP,  
IT Innovation Centre, USFD, IDAC Ireland Ltd., ASD, IBMTP.

## Maxillo-facial Surgery Simulation

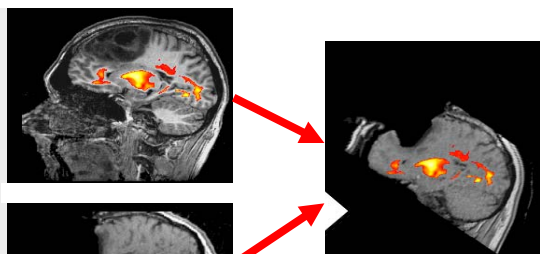


The figures show the simulated position of the bone and soft tissue before and after the distraction process.

In a new technique to correct for facial malformations, a bone-cutting step is followed by use of a rigid external distraction system to move the upper jaw into the correct position. In order to accurately predict the outcome of this treatment, finite element modelling of tissue movements during this process is carried out. Several treatment options can be tried out *in silico* before the most promising one is selected.

## MRI Registration for Neurosurgery

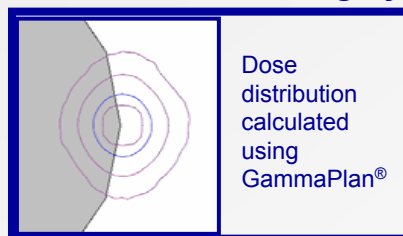
Pre-op anatomical and functional MRI



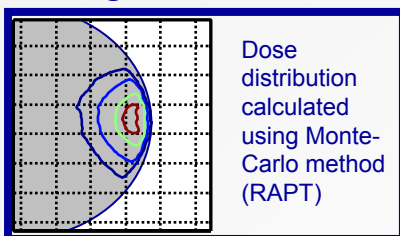
Intra-op anatomical MRI

Non-linear registration to correct for the brain shift phenomenon enc. with image-guided surgical planning. Functional MRI information obtained pre-operatively can then be shown in the correct position relative to the intra-operative anatomical MRI scan. This service is required in quasi real-time during surgery.

## Monte-Carlo Radiosurgery Planning



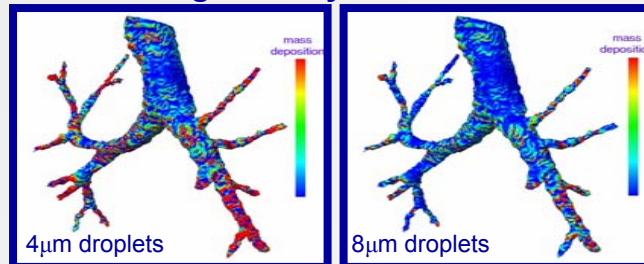
Dose distribution calculated using GammaPlan®



Dose distribution calculated using Monte-Carlo method (RAPT)

The Gamma Knife® uses 201 targeted  $^{60}\text{Co}$  sources to treat brain lesions. At present, the radiation dose distribution is calculated rapidly using GammaPlan®. However, superior results may be obtained using complex, compute-intensive Monte Carlo simulations. These simulations are particularly suited to the Grid because of their parallel scalability. The figures above show that the improvements are especially apparent at the boundary between materials with different attenuation coefficients.

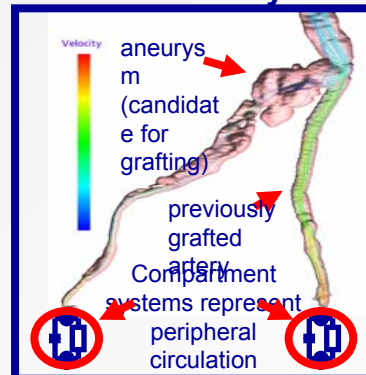
## Inhaled Drug Delivery Simulation



The figures show the deposition of water droplets in the lungs – smaller droplets penetrate deeper into the lungs.

The process of pulmonary drug delivery is affected by many factors, such as inhaler design, formulation of the medication, airway geometry, and the drug absorption process. Computationally demanding 3D fluid dynamics simulation is used to calculate the pattern of air flow, and this step benefits from the use of Grid resources.

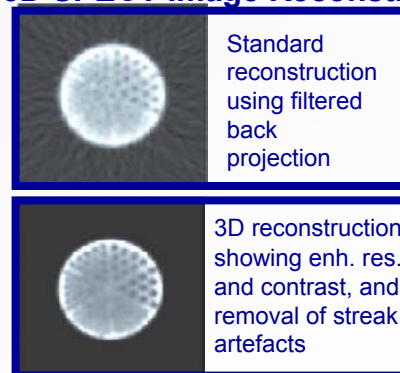
## Cardiovascular System Simulation



Computational fluid dynamics is used to calculate the blood flow in a full 3D model of the section of artery of interest. The properties of the peripheral circulatory are included by coupling compartment systems to the 3D model.

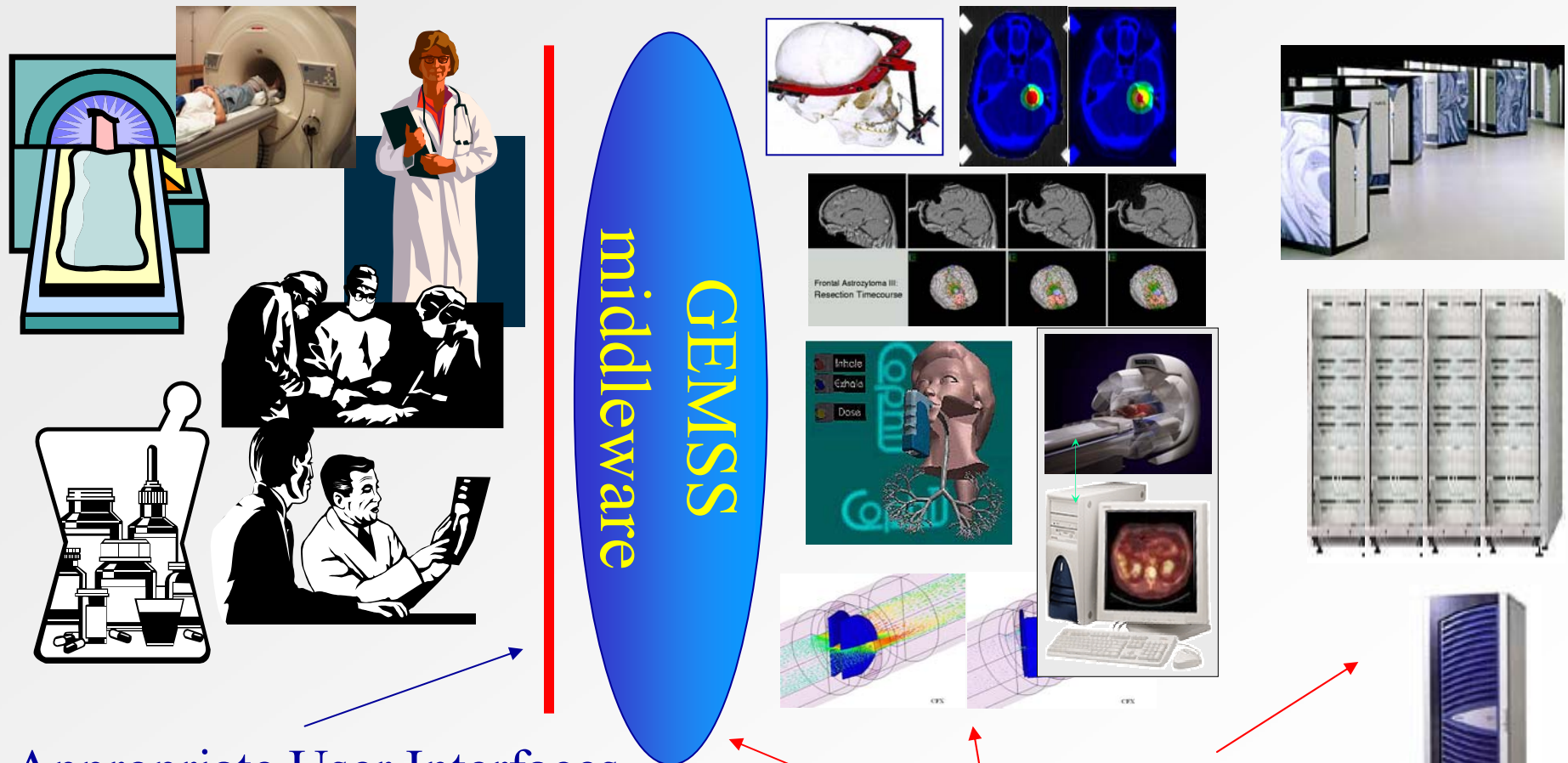
The figure shows blood flow in the iliac arteries – the flow in the left branch is reduced by an aneurysm.

## 3D SPECT Image Reconstruction



Single Photon Emission Computed Tomography (SPECT) can provide valuable information about organ function. Filtered back-projection is a common reconstruction algorithm, but it is only applicable to single slices. Modern fully 3D iterative reconstruction algorithms provide enhanced image reconstruction for the whole image volume, but this comes at the expense of high computational effort. Grid technology will allow wider use of such reconstruction algorithms.

# GEMSS: Technical Goals & Challenges



Appropriate User Interfaces  
& Applications Workflow

Quality of Service  
Negotiation &  
Delivery

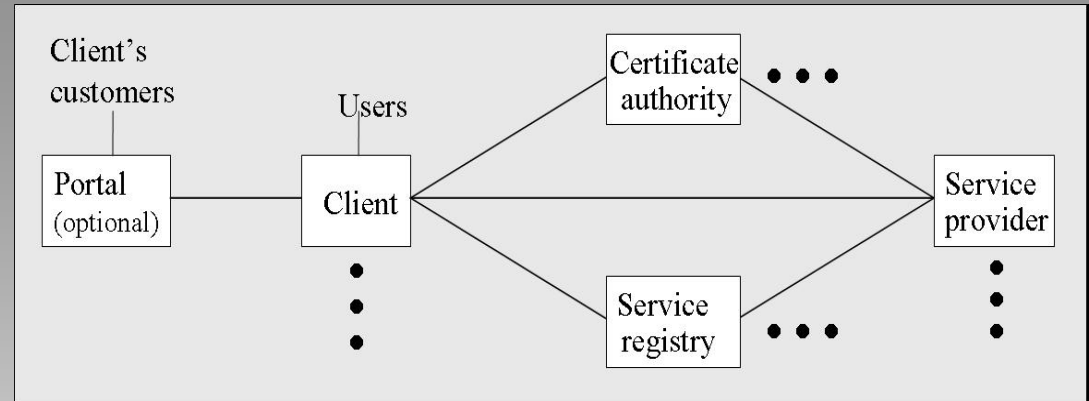
Secure & Legal  
Transmission/Transfer



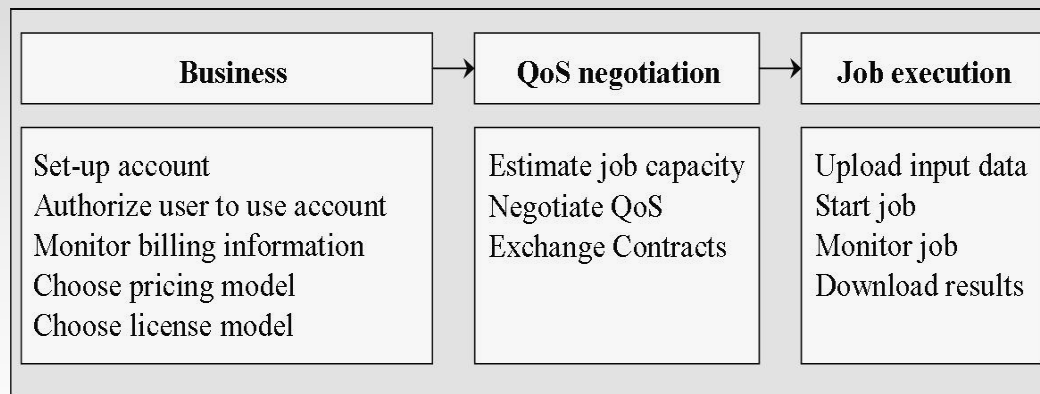
# GEMSS Architecture

## Grid Architecture:

- **Service oriented approach**,
- Based on Web Service technology,
- Interoperability via standards like OGSA,
- Modular component framework,
- Supports flexible workflows:  
Quality of Service (QoS),  
business, application workflow.

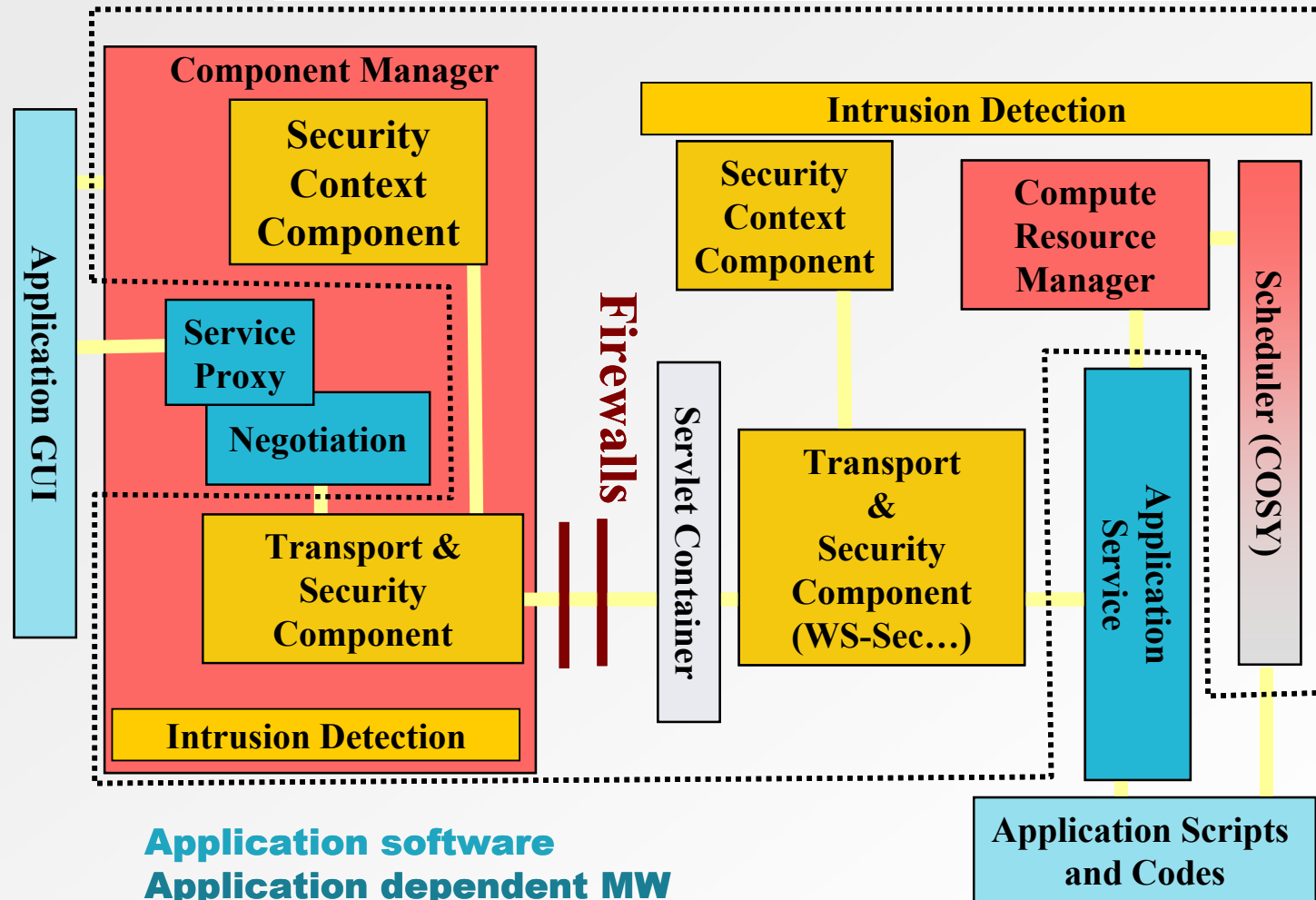


## Three step process model:



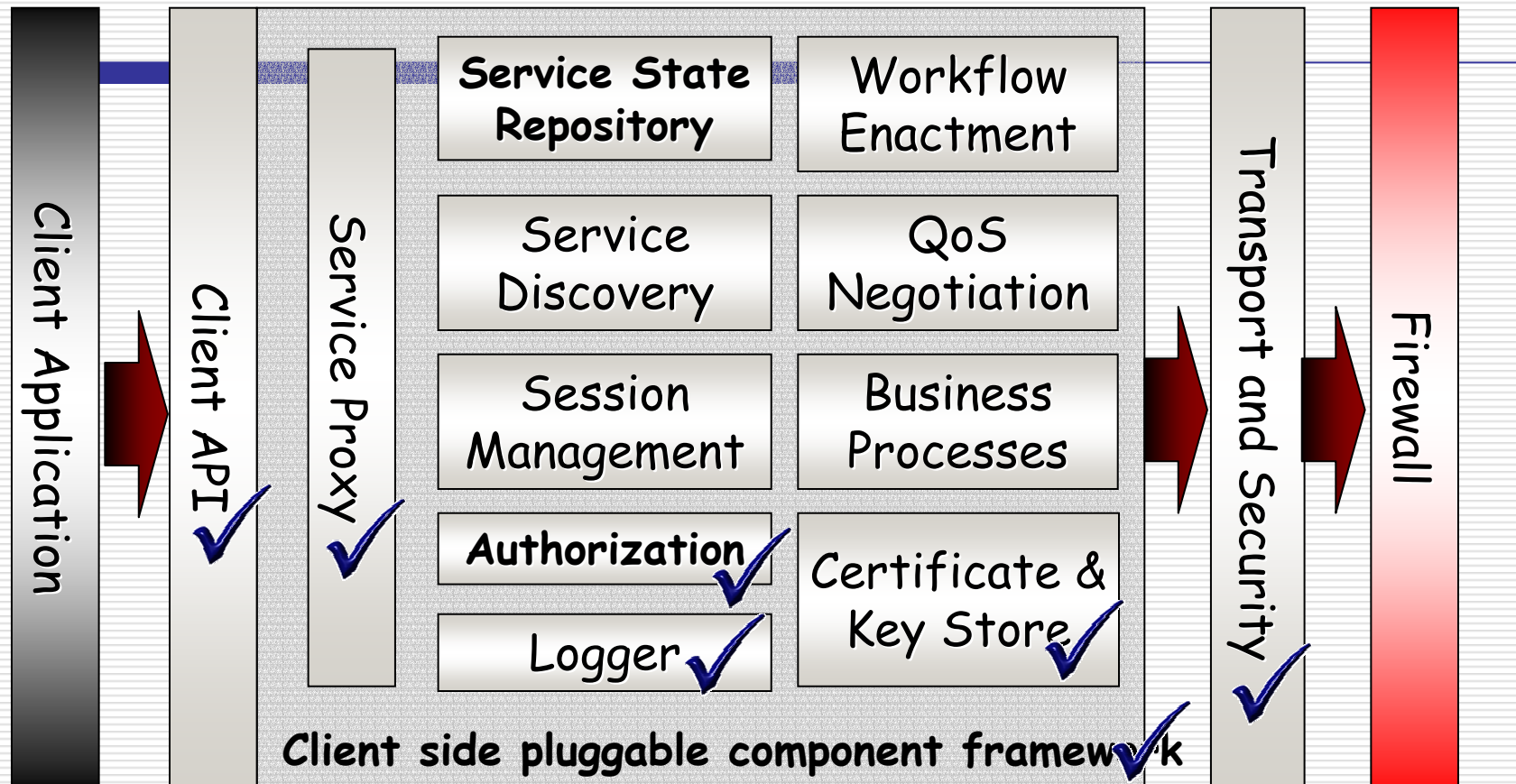
- Flexible business model to allow commercial operation of Grid services.
- Flexible negotiation model: client can negotiate with service providers.
- Quality of service terms can be discussed, as well as the price involved.
- Job execution and data transfer.

# Grid Middleware for simulation services



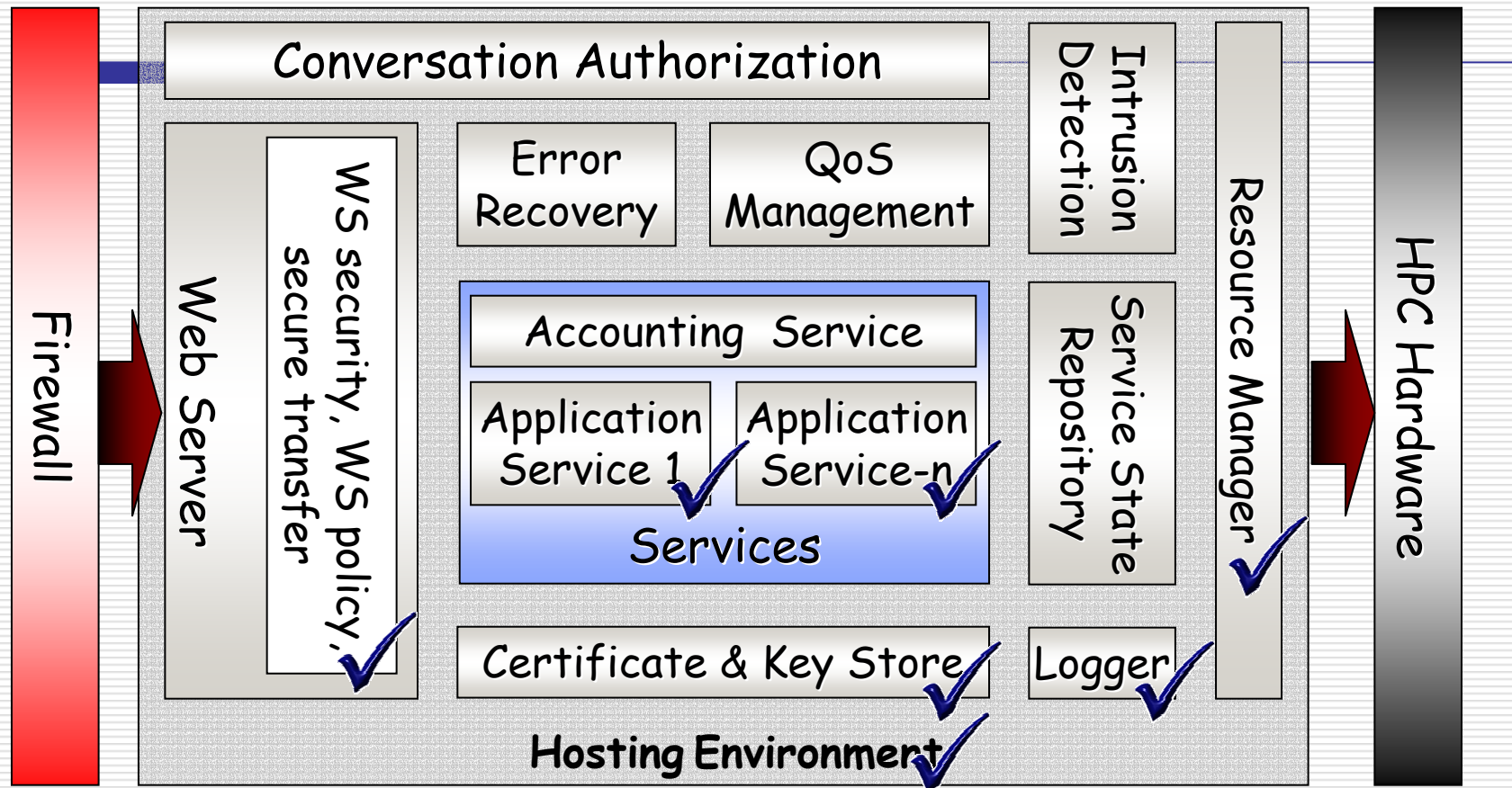
**Application software**  
**Application dependent MW**  
**GEMSS Grid MW**  
**GEMSS advanced security**  
 Standard infrastructure

# Client Infrastructure Implemented in Prototype System



- ☐ Hide Grid-specific details from users.
- ☐ Flexible support for multiple implementations of same component.
- ☐ Allow replacement of components at runtime.

# Service Infrastructure ✓ Implemented in Prototype System



- ❑ Hide complexity of the Grid from the Grid service providers
- ❑ Service provision based on the concept of **Generic Application Services**
- ❑ Support for transformation of HPC applications into Grid services