D5.4 Services Provision

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Dissemination Level		
PU	Public	PU
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

1   Contents

2   Executive Summary

Work package 5 (WP5) of neuGRID is responsible for "Brain Imaging Services Provision". The primary objectives of this work packages were the specification of the brain image analysis services, the adaptation of the existing LORIS code base to allow its integration in the neuGRID infrastructure, and to develop a financial model for future access and support to the brain imaging services. As the neuGRID project will be finalized this month and the details of the activities performed towards the WP5 objectives are described in other deliverables, specifically D5.1-3 and D3.2, this deliverable essentially constitutes a closing statement with regards to these objectives, illustrating that WP5 was successfully completed.

3   Introduction

The neuGRID project aims to provide an infrastructure that supports researchers in analyzing large samples of medical images (e.g., Magnetic Resonance Imaging (MRI) scans of the human brain) and related clinical information using advanced image processing algorithms, pipelines and workflows. In order to achieve this, the specific user requirements of the neuGRID infrastructure were elicited from numerous user groups (see D9.2), leading to several required key components of the system:

- a service oriented architecture that supports the modularity, the abstraction and reusability of the neuGRID components
- a grid middleware backbone that supports the sharing of storage capacity and compute power
- a database for the management of images and related clinical data as well as associated meta-information such as quality control data
- a set of generic services that in part provide abstraction layers on top of functional components (querying service, glueing service), and in part contribute to meeting functional requirements (provenance service, workflow service)
- image processing algorithms and pipelines

The overall architecture, design, and implementation of these components is reported in other deliverables (e.g., D9.2, D5.1, D3.2, D6.1, D7.1, D8.1).

With respect to the contributions of work package 5 to the neuGrid system, the objectives of work package 5 (WP5) as listed in the original neuGRID Description of Work (DoW) were:

- Specify brain image analysis services

- Adapt existing code-base to meet regulatory approval needed for end-user acceptance

- Interface LORIS code base with the grid middleware technology

- Demonstrate proof-of-principle that existing LORIS databasing and analysis capabilities will function transparently within a grid network

- Develop end-user interfaces to interact with the brain imaging services

- Develop a financial model for access to services by different end-user communities

- Develop human resources to support the services to be made available.

This remainder of this deliverable briefly summarizes the accomplishments made towards each of these objectives, with references to other deliverables that cover the relevant detail.

4   Specify brain image analysis services

This refers to the specification of the image processing tools and algorithms to be made availble to neuGRID users. A detailed description of these tools, broken into 2 different «tiers», was described in D5.1 *Brain Imaging Service Portfolio Specification*. Tier 1 reflected the algorithms part of/necessary for running the cortical thickness extraction algorithm "CLASP"[1], identified as a test bed and minimum requirement for neuGRID, while Tier 2 contained everything else. Clearly this inventory of algorithms will never be "finished", as one of the fundamental principles underlying neuGrid is for it to be expandable with data and software tools; as such, D5.1, and then specifically Tier 1, described an initial collection of tools available in neuGrid. Proving the expandability of neuGrid, many other software tools and algorithms have since been deployed in neuGrid; see D10.3 *Gridified Toolbox Year3 Portfolio & Report* for more details.

5   Meet regulatory approval

The task to be accomplished here was to adapt existing code-base to meet regulatory approval needed for end-user acceptance.

After a detailed review of regulatory requirements in the European landscape, it was concluded that for the current deployment of the neuGRID infrastructure, as a scientific research tool, that the neuGRID code base is not required to meet strict regulatory requirements. The survey and its conclusions can be found in D5.2 *Regulatory Guidelines Document for Code Development*.

6   LORIS – grid interface

This goal included interfacing LORIS code base with the grid middleware technology; proof-of-principle demonstration that existing LORIS databasing and analysis capabilities will function transparently within a grid network.

These two objectives were achieved through the development and deployment of Loris-X in the neuGRID infrastructure. The Loris-X solution was initially based on the LORIS technology developed at the Montreal Neurological Institute for the NIH-funded *MRI Study of Normal Brain Development*[2], which was completely refactored into the Loris-X solution by

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[1] Kim JS, Singh V, Lee JK, Lerch J, Ad-Dab'bagh Y, MacDonald D, Lee JM, Kim SI, Evans AC. Automated 3-D extraction and evaluation of the inner and outer cortical surfaces using a Laplacian map and partial volume effect classification. Neuroimage, 27:210-21, 2005

[2] Evans AC; Brain Development Cooperative Group. The NIH MRI study of normal brain development. Neuroimage, 2006 Mar; 30(1):184-202

consortium partner Prodema Medical in order to address the abstraction and modularization requirements for neuGRID. A detailed report on the implementation and performance of Loris-X within neuGRID can be found in D3.2 *Database Implementation and Performance Report*. Since this work was the main focus of work packages 3 and 5, a few paragraphs of the performance summary are summarily reproduced here:

Prodema hosts, in its server room, a pair of Dell PowerEdge (PE2950 and PE1950) rack servers to provide databasing support for the neuGRID production environment. The PE1950-1 with its 8 core Xeon E5430@2.66 GHz and 8GB Ram hosts the MySQL databases server as well as the apache+tomcat web server and service container. The PE2950 acts as the network file store, with a 2TB disk mounted on PE1950 over the intranet. The Internet connection to Prodema's servers is a symmetric, 10MB/s service provided by Swisscom.

The database is populated with a data dictionary that includes 811 clinical variable descriptions (MetaVariable, defining name, data type, possible values, etc...) and 47 examination template definitions (MetaExamination, defining the notion of different clinical examinations).

Data import is still ongoing, as explained in the design section; images go through a two-phase import process that gets them fully registered. At the time of this writing, 2589 MRI images are fully registered in the database. Clinical information includes 52245 examination records that are associated to 6481 study events of 1336 different subjects.

The Loris-X user interface has been integrated with the neuGRID portal […][3] with the necessary functionalities exposed to users authenticated against the neuGRID VO […]. The users use the subject and image browsing interfaces […] to navigate within the database, and the image viewer interfaces to perform quality […]. Construction of queries is also possible using directly the Loris-X […], or other interfaces that connect to Loris-X via the querying service.

[…] With the current data population, all queries we tested run within web-time, i.e. within the time which is necessarily taken up by HTTP traffic both ways, request parsing, response construction and client-side rendering. For comparison, with all optimizing features switched off, we estimated this to be around 500-fold speed increase (lower bound).

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[3] Part of the text, not relevant for the quotation here is omitted for brevity.
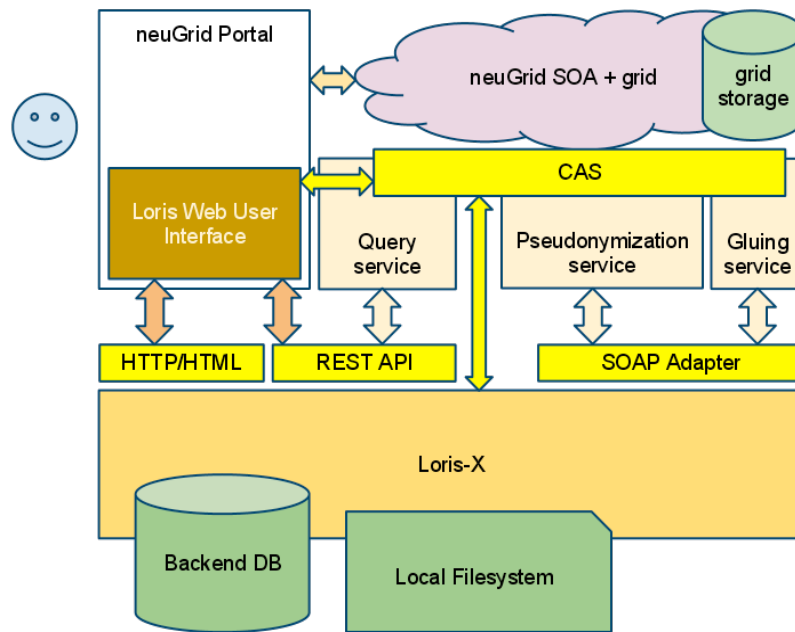
Figure 1 Loris-X Integration Points in neuGrid

7 End-user interaction with the brain imaging services

A number of interfaces have been developed for use within neuGRID. The «facade» of neuGRID is a web portal developed by consortium partner Healthgrid. Through this portal the user has access to a number of other interfaces, notably the Loris-X interface that allows for image quality control and acceess and querying of the image- and clinical data stores (see D3.2), and the LONI Pipeline[4] interface that allows the user to formulate image processing workflows or «pipelines».

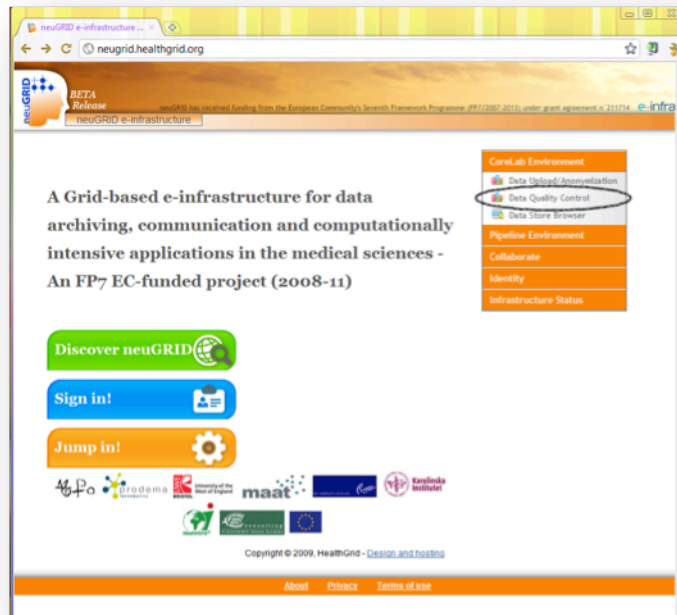[4] LONI: UCLA Laboratory Of NeuroImaging http://www.loni.ucla.edu
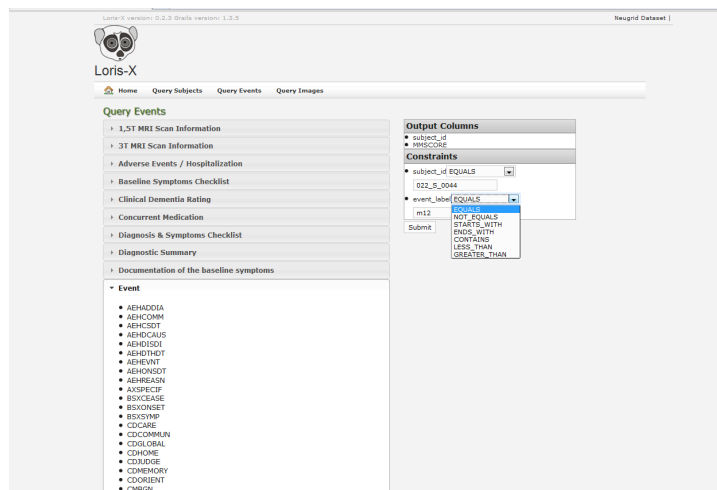
Figure 2 NeuGrid Portal

Figure 3 Image Cohort Filtering – preparation of the dataset for the pipeline interface

8 Financial model and human resources.

This objective encompasses two goals: to develop a financial model for access to services by different end-user communities; and to develop human resources to support the services to be made available.

The post-project, future sustainability of the neuGRID infrastructure is obviously an essential aspect of a large-scale, multinational project such as neuGRID. In the original DoW, two deliverables were defined with considerable overlap, being D4.5 *Post Projects Sustainability Report* and D5.3 *Brain Imaging Services Business Models Report.* In the second half of year 3 of the Project it was decided to merge these two deliverables into one single document that was delivered in October 2010. This document describes, in detail, the considerations required for post-project sustainability and outlines the various models that might be

followed. The actual realization of a post-neuGrid infrastructure requires the neuGrid consortium to reach agreement about the details of its implementation.

9   Conclusion

This deliverable summarizes the "services provision" attained by work package 5 and, to some extent, work package 3. Since the details of the development performed in these work packages has been described in a number of other deliverables, this document merely summarizes the objectives of WP 5 and briefly describes how these objectives were reached during the course of the Project, with references to more detailed deliverables.

In summary, the neuGRID-integrated Loris-X solution meets the established functional requirements of neuGRID and is currently deployed and was benchmarked as part of the neuGRID distributed infrastructure, demonstrating that the neuGRID database implementation has been successfully carried out and the resulting deployment is an organic, key part of the neuGRID application suite. In addition, a number of non-technical deliverables were developed, successfully concluding work package 5.