



## LHDL: The Living Human Digital Library

Every hospital, every research laboratory in Europe has a wealth of biomedical data locked-up somewhere that, if shared with other experts, could dramatically improve healthcare practice as well as the development of better biomedical products. LHDL finally makes it possible to share biomedical data in an easy, controlled, safe, and financially viable way. One click to upload all your data to your private space; one click to share each dataset only with those you choose; a third click to publish your data within an e-commerce service, to which access is sold at the price you set.

### Objectives of the project

**Context:** The Living Human Project (LHP) is a grass-roots initiative aimed at developing an *in silico* model of the human musculo-skeletal apparatus that can predict how mechanical forces are exchanged internally and externally, from the whole body down to the protein level, consistently with the scope of the Physiome project. To pursue this very ambitious objective, it is necessary for large research communities to share highly heterogeneous collections of data and models through a repository fully integrated, and directly accessible by any researcher in the world. Although inspired by a specific community, this problem is very general in nature, and its solution will significantly and positively affect European research, clinical and industrial practices.

**Project:** The Living Human Digital Library (LHDL) aims to develop and deploy the resource-sharing infrastructure required by the LHP community and by many other similar groups involved with biomedical research and practice. In particular, the project is developing:

- *LhpBuilder*, an application for the interactive visualisation, processing and fusion of biomedical digital data;
- *LhpRepository*, an ICT infrastructure fully integrated with *LhpBuilder* for the management and the sharing of digital resources relevant for biomedical research;
- *LhpSimul*, a service framework for the development, sharing and choreography of data processing services.

Once completed, these three elements will form the most powerful biomedical data management service in the world.

### Project Description

**Project Description:** *LhpBuilder* is a fat client software application that is being developed through the Multimod Application Framework, a European open source software framework for the creation of computer aided medicine applications. With *LhpBuilder*, every researcher can import virtually any type of biomedical data (including medical imaging, biomedical instrumentation recordings, motion analysis data, numerical modelling results, etc.) in dozens of popular formats. Once all the data are imported, they can be organised in space and time thanks to a number of powerful data fusion techniques. They can also be explored using some of the most powerful visualisation algorithms available, exposed in a fully interactive environment, within which the user can operate with extreme simplicity using a complete Graphic User Interface. 1D, 2D, 3D, and 4D data can be combined, merged, and fused in synergistic ways.

Once the data collection is ready, it can be uploaded with a single mouse click to the *LhpRepository* service. Each dataset is encrypted and uploaded through a secure channel to the remote repository, where it is stored in the user's sandbox. Through a web interface the user can see all her uploaded datasets, annotate them, curate them and decide with whom she wants to share each of them. The annotation is performed according to the LHDL Resource ontology, an advanced ontology that makes possible all most sophisticated data management services, including complex access management, traceability, data integrity assurance, semantic search services, etc. The tight integration with the *LhpBuilder* fat client makes it possible to compile automatically much of the metadata, reducing the curation work that users have to do.

### Scenario:

Part of the LHDL technology will be used by B3C, a CINECA spin-off, to deliver the first commercial biomedical data management service, fully integrated with the popular [Biomed Town](#) Internet community. The service, called *PhysiomeSpace*, is expected to enter the beta phase in the last quarter of 2008, and to start full service in the first half of 2009. Any Biomed Town user will have a free account in which up to 1 Gb of data can be stored and shared with any other user; additional space will be available for a small fee. Users will also be able to *publish* their datasets, which will then be downloadable at the cost set directly by the data owner; it will be possible to set different price tags for profit and non-profit uses.



Once the datasets are stored in the sandbox, another option is to process them with the available execution services. The LHDL Resource Ontology presents both data and service resources in the same semantic space; thus, it is possible to select some data, search for all available services that can process that data type, and choose the one we need, with only a few mouse clicks. The results of the processing are also stored in our sandbox, ready to be shared or downloaded.

The potentially complex orchestration of the services as their number increases is simplified by the use of a semantic broker that can orchestrate many services into a single goal. Goals are stored as

***LHDL is developing and deploying the resource-sharing infrastructure most VPH projects need***

services, so the user can request a goal service as a single processing action though, in reality, it is the concatenation of multiple execution services run according to a semantic rule.

Given that all these objectives have already been achieved, at least in prototypical form, we are confident that, by the time of its completion, the LHDL project will provide the biomedical research community and the European healthcare and biomedical industries with a set of highly innovative and truly enabling e-health technologies for data management.

### Expected Results & Impacts

- *PhysiomeSpace*, the first data management & sharing service dedicated to biomedical data;
- *LhpBuilder*, best biomedical data fusion software fully integrated with PhysiomeSpace data management services;
- *LhpSimul*, a powerful architecture of execution web services for the distributed execution of data-intensive algorithms;
- *LhpSWS*, semantic web services with full semantic brokering capable of combining storage and execution services in complex data processing flows;
- the largest collection of experimental and modelling data on the descriptive anatomy, the functional anatomy and the multiscale biomechanics of the musculoskeletal system; this collection will be deployed and shared with the worldwide research community through the PhysiomeSpace service.

### LHDL: the Living Human Digital Library

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*Timetable:* from 02/06 – to 01/09

*Total cost:* € 3,238,320

*EC funding:* € 2,250,520

*Instrument:* STREP

*Project Identifier:* FP6-IST-2004-026932

**Keywords:**

Physiome,  
Virtual Physiological Human,  
Living Human Project,  
digital libraries,  
data sharing,  
semantic web services,  
data fusion.