(BW) - eLabs -

Knowledge Management for Virtual & Remote Labs

eSciDoc Days 2009
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Overview:

I. Background – Cooperative Knowledge Spaces
II. Collaborative Experiments in Virtual and Remote Labs
III. Architecture and Components of the BW-eLabs project
IV. Conclusion
I Background –

Cooperative Knowledge Spaces
Information Systems in Academic Education:

- **First Generation:**
  - Information distribution
  - Document management
  - Passive and static objects by the majority
  - "Simple" training scenarios
  - Standard communication tools

- **Next Generation:**
  - Modular and flexible knowledge components
  - Dynamical course composition
  - Interactive andurnative learning scenarios
  - Supports explorative learning strategies
  - Integrated applications for cooperation

Current systems:
- **Clix**
- **Ilias**
- **Blackboard**
- **WebCT**
- **moodle**

Support of Individual Learning Process

in use in many national and international universities

Object of current research and development
Content Centric versus Community Centric

- **content centric:**
  The content elements form the center of the system and its technological design,
  communication and cooperation are missing or are arranged "around" the content elements

- **community centric:**
  Communication and cooperation between the actors form the center of the system and its technological design,
  content elements are embedded into this "cooperation infrastructure".

"traditional approach“, basis of the majority of the common eLearning platforms

"eLearning spaces of the future“, CSCW / CSCL approach, currently under research
Cooperative Research Spaces in Natural Sciences & Engineering

- Virtual "worlds" with generalized space metaphor
- Serve for knowledge acquisition, knowledge organization and knowledge management
- Focus on cooperation between humans and related processes

- Allow modification, annotation, linking and combination of all existing resources from multiple sources with flexible user groups, role management and autonomous administration
- Contain resources for experiments in natural sciences and engineering
- Transparent management and reuse of experimental primary data

- Cross-link with scientific literature (digital libraries) and scientific document management systems
- Integrate existing components

- Serve for academic EDUCATION AND RESEARCH, smooth transition
II Collaborative Experiments in Virtual and Remote Labs
Remote Experiments ...

... are real experiments in real labs remote controlled by the experimenter outside the lab.

Remote experiments provide research on real physical systems gaining hands-on experience.

Virtual Labs ...

... are virtual spaces built after real labs. Here, experiments can be designed, built and accomplished computer-aided.

In addition to the execution of an experiment, virtual labs represent the process of experiment design and set-up, as well.

Both support generally the direct integration of external tools (i.e. components from other labs, CAS, numerical tools).
Use Cases of Virtual Labs and Remote Experiments:

in theoretical domains:
- Mathematics
- Theoretical physics
- Theoretical chemistry
- Theoretical domains of engineering

in experimental domains:
- Experimental physics
- Experimental chemistry
- Experimental domains of engineering

Experimental access to abstract objects (VL)
Exploration of abstract concepts (VL)
“Trial-and-Error”-access to new insights (VL)

Increase of capacity for experiments
Availability of additional experiments
Safety aspects
Physical effects visualized in situ (VL)
“Hands-on” experience (RE)
Permanent access (24/7)
Independent from equipment
Independence from place
Remote Experiment „Hysteresis“ – Assembly:

Hysteresis and phase transition of ferromagnetic material;
„Ferromagnetism phenomenologically“

Remote Farm TU Berlin: Concept Thomsen/Scheel
VirtLab – Spin-Spin-Interaction in a Ferromagnet

„Ferromagnetism microscopically“
Multiple User Interfaces for Multiple Applications and User Groups

- GUI I: Demo-applet (motivation)
- GUI II: Java-application (simple experiments)
- GUI III: Oorange (research scenarios)

I: ... as Applet

II: ... as Java-application

III: ... in Oorange, with Maple (Pinkall et.al., TU Berlin)
Example: Architecture of a “Virtual Lab“ (VideoEasel)

User / Identity Management

“Virtual Lab“ (Simulation & Computation)

Interfaces

External Virtual Labs

Connectors

Intelligent Assistants

Front-end

Browser/Interface

alternative user interfaces

External numerical Software & CAS

integration of external tools

cooperative use
Use Cases for Cooperation:

- Session sharing, scenario “Shared experiments in remote teams”
- Session sharing, scenario “Demonstration”
III Architecture and Components of the BW-eLabs project
Project BW-eLabs – Background and Aim

Initial situation:
- Nanotechnology: exploration of nanoscopic objects
- Enormous efforts and costs for experiments (i.e. clean rooms, instruments for microwave synthesis and analysis, electron microscopes)
- Result: research restricted to a small scientific community
- Nanotechnology: key technology for 21st century

Aim:
- Ameliorate the access to equipment for (nanotechnology-related) experiments for many users
- Cross-linking and integration of existing virtual and remote-controlled labs as well as research information in one cooperative knowledge space
- Infrastructure for communication and cooperation
- Integrated document management system to archive primary data and traceability of results (evanescent and dynamic data)
**Project BW-eLabs – Key Data**

- **Project period and funding:**
  - 2 ½ years beginning July 1th, 2009 as eScience project
  - Funding by MWK Baden-Württemberg

- **Partners:**
  - University of Stuttgart (RUS, IITS, ITO, UB)
    - Consortial management (S. Jeschke), project management, main server hosting
    - Overall architecture, virtual labs, digital holography, connection to digital library
  - FIZ Karlsruhe (Fachinformationszentrum)
    - Upgrade and provision of eSciDoc (scientific document management system)
  - Freiburg Materials Research Center (FMF) and Computing Center of University of Freiburg
    - Provision of virtual and remote labs, hosting of mirror server
  - Stuttgart Media University
    - Usability, security, reproducibility
  - Business partner: SUN
    - 3D-Engine Wonderland
eScience/eResearch-Scenarios
for Natural Sciences and Engineering

- Open framework
- for complex experiments
- cross-linked by Web Services / Semantic Web Technologies
- Open source – open content – open access
Nanotechnology Components in BW-eLabs

Synthesis

- Microwave synthesis

Analysis

- Small Analysis
- Photoluminescence Spectrometer
- Electron Microscope
- Large Analysis

Application

- Tailor-made Material-development
  - Doping of Nanoparticles
  - Development of Hybrid-systems
  - Integration in Def. Structures

Remote Experiments

Virtual Laboratories

Data-Analysis-Software

Realization by Freiburg Materials Research Center FMF


**Added Value:**

- **Generally:**
  - Access to expensive research equipment and methods (Large or specific instruments, specialized research equipment)
  - Extended possibilities for scientific cooperation (promotion of national and international research connections).
  - Research knowledge is long-term saved and indexed
  - Integration into databases avoids doing unneeded “doubled research”

- **Specific:**
  - Efficient and systematic development of new materials
  - Constant quality of produced material provides better (repeatable) research results
  - Quality check for synthesis instructions
  - Established methods for material synthesis as demonstrations in academic education
  - Autonomous generation of digital labs journals:
    All results with required parameters and all steps “Synthesis → Characterization → Use” are unified and described clearly arranged.
Scientific Document Management with eSciDoc

**Background:**
- Funded by BMBF, 2004-2009
- Cooperation of FIZ Karlsruhe and Max Planck Society
- Open source philosophy: Common Development and Distribution License (CDDL) in version 1.0
- Core infrastructure built on existing open source software (PostgreSQL, JBoss Application Server, Tomcat Servlet Container, Fedora (Flexible Extensible Digital Object Repository Architecture))
- [http://www.escidoc.org](http://www.escidoc.org)

**Aim and organization:**
- Contains basic functionality (eSciDoc Infrastructure), and domain- or task-specific applications (eSciDoc Solutions)
- Services for object storing, search and indexing, statistics, persistent identification, workflows, validation, transformation, ....
- Modular design, service-oriented architecture
Embedding in 3D-Engine – Acceptance and Usability

- Three-dimensional representation
  (based on Wonderland, SUN, open source engine)
- Realistic metaphors enable intuitive use of software applications
- Reduction of complexity without constriction on use
- Development and testing of new technologies for information visualization
Complementary European Project “LiLa“ – Key Data

- **Aim and Challenge:**
  - Cross-linked virtual labs for academic education
  - LiLa: Library of Labs
  - Same architecture as BW-Labs, integrated and combined operation of BW-eLabs and LiLa infrastructure
  - Higher access rates: New challenges related to scalability
  - New challenges related to support for students in these systems
    (less scientific previous knowledge of this target group)

- **Projects period and funding:**
  - 2 years beginning in June as eLearning project
  - Funding by EU, CIP
  - 10 European partners
  - Consortium leader: University of Stuttgart
Under Evaluation: DFG Project “NetLabs“ – Key Data

- **Aim and Challenge:**
  - Call: Virtual Research Environments
  - Main approach of the project: transfer project of the BW-eLabs project
  - Additional nanotechnological experiments (geographic transfer),
    new engineering experiments from the fields of robotics (transfer towards new disciplines)
  - “NetLabs - Networked Virtual & Remote Laboratories for Research Collaboration in Sciences & Engineering“
  - New challenges related to the higher diversity of the experiments
    (challenges in particular for usability, interface design, …)

- **Projected period and funding (IFF granted):**
  - 2 years beginning in January 2010 as eScience project
  - Funding by the DFG (German Research Foundation), requested
  - Partners:
    - Academic: Univ. of Stuttgart, FIZ Karlsruhe, RWTH Aachen, TU Berlin
    - Industrial: SUN, KUKA robotics
  - Consortium leader: University of Stuttgart
IV Conclusion
Main Requirements for BW-eLabs Network: Integration

- Interoperability (integration on technology level):
  - Integration of experiments and lab components from different sources
  - Assembly of complex experiments from components
  - Dynamic set of available components
  - Development of peer-to-peer models for cooperation of ad-hoc/mobile users
    - Integration technology based on Web Services
    - and models for dynamical combination of components

- Interconnectedness (integration on content level):
  - User-adaptive, domain-related linking of resources for experiments
  - Semantic, standardized description of abstract resources and components
  - Intelligent management of collaborative acting, i.e. cooperative experimenting and distribution of results
    - Domain-specific ontologies, Semantic Web technologies,
    - models of dynamic process composition and orchestration
Requirements of Identity Management Systems

- Student Uni X1
- eResearch Portal Uni X1
  - Degree Program
  - VirtLab A
- IdMan X1
- exchange primary data
- integration lab components
- integration scientific paper
- license request
- Associated University Double Degree
  - Degree Program
- IdMan X2
- eResearch Portal Uni X2
  - RemLab
- eResearch Portal Uni X3
  - VirtLab C
- National Library
- Provider License Server
- IdMan S
- IdMan X2
- IdMan X3
- IdMan L
- IdMan S

S. Jeschke
Potential and Development

- IT-Technologies have multiple capabilities
to ameliorate and intensify scientific education and research:
  - Enhancement of available resources
  - Visualization and “grabability” of abstract objects and concepts
  - Optimization of spatial distributed resources
  - „Democratization“ of research

- Smooth transition between education and research
  ("Unity of education and research")
  - Holistic approach for use of New Media and IT-technologies
    in education (eLearning / eTeaching) and research (eResearch / eScience)

- Overcoming of geographical borders:
  - New cooperative efforts in “hybride” academic education over the Web
  - New models for the realization of geographically distributed courses of study
  - New capabilities for geographical distributed research projects
Thank you for your interest!

Questions?
Back-Up Slides
VirtLab 1 – Constant Magnetic Field (H=0)

start, temperature low

later, temperature still low

later, and temperature now significantly higher

Pictures from Virtual Lab VideoEasel: designed by Richter/Seiler
VirtLab 2 – Constant (Low) Temperature

now: ext. field = 1 (low)

later: ext. field = 1 (low)

much later, ext. field still = -1

ext. field = -8

later, ext. field still = -8

much later, ext. field still = -8
Weiss-Domains in Real Experiments

The rules of dynamics favour neighbourhoods of identically oriented elemental magnets, resulting in the zones of identical magnetization:

Weiss Domains, observed due to the Kerr-Effect
III From eLearning to eScience/eResearch
Location: Stuttgart / Germany

- Federal state: Baden-Württemberg
- University of Stuttgart:
  - Institute of Technology
  - 20,000 student, more than 300 professors

*Stuttgart, Capital of BW*
…Located in the Middle of One of the Economically Most Powerful Regions of Europe:
On Campus Close Cooperation with ...

- DLR - German Aerospace Center
- Max-Planck Institutes
- Fraunhofer Institutes
- Universität Stuttgart
eLearning – eScience politics in Baden-Württemberg

- **Funding situation in Germany:**
  - Since 1995, numerous calls for eLearning and related activities, mainly funded by the BMBF (Federal Ministry of Education and Research)
  - Since 2006, total stop - due to the so-called reform of the federal organisation of the German state
  - As a result, “run” on the few programs financed by the EC (European Commission)
  - Unfortunally, very few funding efforts by the DFG (German Research Foundation)

- **Baden-Württemberg:**
  - Supplementary funding programs since approx. 1995, additional to BMBF and others
  - Still ongoing!
  - New focus towards eScience and eResearch (and integration of eLearning and eScience)
  - Since 2009: funding of the project BW-eLabs

- **New Tendency:**
  - Additional funding programs by the DFG