Networking Nanotechnology-
Resources for Scientific
Education and Research with
BW-eLabs

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Freiburg Materials Research Center (FMF) and
Computing Center of University of Freiburg
Stuttgart Media University
Business partner: SUN
What's Special about Stuttgart?

- Stuttgart:
  - ~ 595,000 inhabitants
  - ~ Town of Porsche, Mercedes, Bosch, IBM …
  - ~ Town of Vineyards and Mineral Spas
  - ~ Research University with high Third-party funding per professor - 1st place in Germany
  - ~ 20,000 Students at the University of Stuttgart in 10 Faculties
Stuttgart: A Research University with a focus on Engineering and Natural Sciences

Astronautics Centre

High-Performance Computing Centre

Research Centre for Simulation Technology

VISUS

SOFIA

Europe's largest driving simulator
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
Background - Cooperative Knowledge Spaces
Information Systems in Academic Education:

■ First Generation:
- Information distribution
- Document management
- Passive access to objects by the majority
- "Simple" training scenarios
- Stand-alone communication tools

■ Next Generation:
- Modular and flexible knowledge components
- Dynamical course composition
- Interactive and user-adaptive
- Complex training scenarios
- Supports explorative learning strategies
- Integrated applications for cooperation

Object of current research and development

in use in many national and international universities

Support of Individual Learning Process

Organization of Studies

Clix  Ilias  Blackboard  WebCT  moodle
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 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
Collaborative Experiments in Virtual and Remote Labs
Remote Experiments ...

... are real experiments in real labs remotely 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 & Multiple Groups

- GUI I: Demo-applet (motivation)
- GUI II: Java-application (simple experiments)
- GUI III: Oorange (research scenarios)
Example: Architecture of a “Virtual Lab“ (VideoEasel)

- User / Identity Management
- “Virtual Lab“ (Simulation & Computation)
- Interfaces
- Connectors
- Intelligent Assistants
- Front-end
- Alternative user interfaces

Connections:
- Integration of external tools
- Cooperative use
- External Virtual Labs
- External numerical Software & CAS

- Browser/Interface
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 21th 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

- Digital Library
- Scientific Document Management
- Process Support
- Service Broker

3D-World

Analyzer 1, Analyzer 2, Analyzer 3

VirtLab A, VirtLab B, VirtLab C

TEM, AFM, SEM

cooperative use of (High-end) devices

- 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
- Large Analysis
- Electron Microscope

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

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

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