Research in the ActiveMath Project

Pedagogy, Mathematics, Web!

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Projects' History

- VIL (BMBF) 2000-2001
- In2Mat (BMBF, partner UdS) 2001-2003
- MMISS (BMBF, partner UdS) 2001-2003
- MIPPA (DFG, 2002-2004)

- LeActiveMath (EU, coordinator) 2004-2006
- iClass (EU, partner) 2004-2008
- Mathe Führerschein (Arbeitgeberverband Gesamtmetall) 2004

- Kaleidoscope (EU, partner UdS)
- ProLearn (EU, partner DFKI)

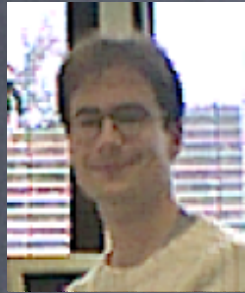# Pedagogical goals
(first phase)

- Personalization and adaptation
  - content
  - presentation
  - feedback
- usability of content presentation
- some self-responsability
- active exploratory learning
- target audience: University undergraduate

Technical goals

(first phase)

- web delivery

- separation of content and functions

- promote re-use of content

- several presentation formats

- standardized encodings

- open, distributed architecture
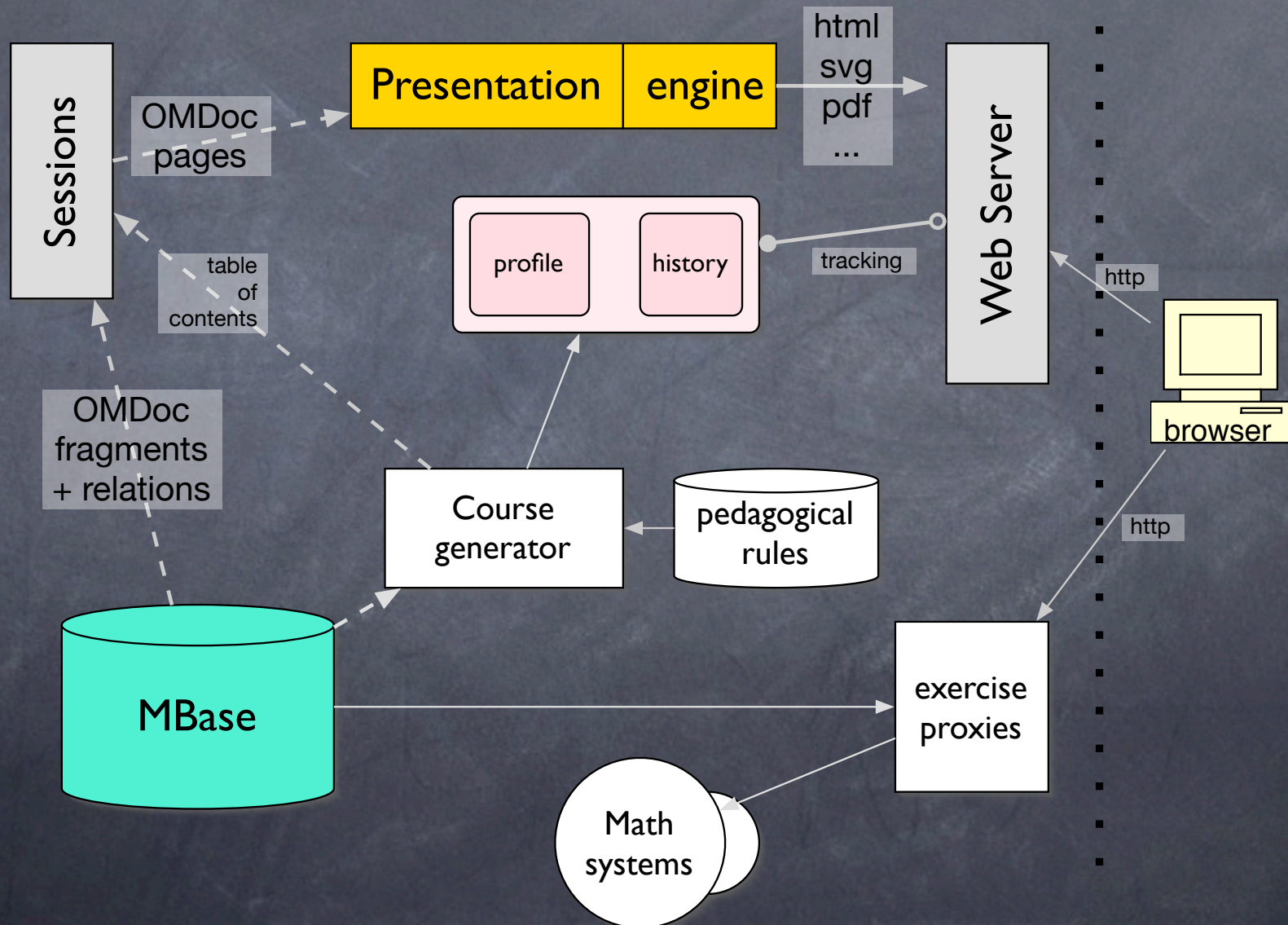
- platform independence

ActiveMath 2003

and many more!

- personalized content and presentation
- interactive exercises with math–systems
- distributed architecture
- prototype suggestion
- OMDoc encoding, with pedagogical metadata

ActiveMath architecture

OpenMath in action: presentation process

- Content is in OMDoc
    - items with text and formulae
    - formulae in OpenMath
    - metadata
- Is transformed to presentation
    - extensible XSLTs
    - velocity combination
    - global styling

OMDoc example: 1

A monoid is a   structure
 [M times unit]

in which
[M times]

is a semi-group

with unit
e

OMDoc example: 2

```
<definition id="c6s1p4_Th2_def_monoid" for="c6s1p4_monoid">

<CMP >
A monoid is a                              structure
 [M times unit]


in which
[M times]

is a semi-group
with                                       unit
e

</CMP>
<FMP><OMOBJ> ... </OMOBJ></FMP>
</definition>
```

OMDoc example: 3

```
<definition id="c6s1p4_Th2_def_monoid" for="c6s1p4_monoid">
<metadata>
    <extradata><depends-on>
     <ref xref="cp1_Th3/structure" />
    </depends-on></extradata>
  <Title>Definition of a monoid</Title>
  </metadata>
<CMP>
A monoid is a                                          structure
 [M times unit]



in which
[M times]



is a semi-group
with                                           unit
e

</CMP>
<FMP><OMOBJ> ... </OMOBJ></FMP>
</definition>
```

OMDoc example: 4

```
<definition id="c6s1p4_Th2_def_monoid" for="c6s1p4_monoid">
<metadata>
   <extradata><depends-on>
     <ref xref="cp1_Th3/structure" />
   </depends-on></extradata>
  <Title>Definition of a monoid</Title>
  </metadata>
<CMP>
A monoid is a <ref xref="cp1_Th3_def_structure"> structure </ref>
 <OMOBJ>
<OMS cd="elementary" name="ordered-triple"/>
   <OMV name="M"/> <OMS cd="cp4_Th2" name="times"/> <OMS cd="cp4_Th2" name="unit"/>
</OMOBJ>
in which
<OMOBJ>
<OMS cd="elementary" name="ordered-pair"/>
   <OMV name="M"/> <OMS cd="cp4_Th2" name="times"/>
</OMOBJ>
is a semi-group
with <ref xref="c6s1p3_Th2_def_unit">unit</ref>
<OMOBJ>
   <OMS cd="cp4_Th2" name="unit"/>
</OMOBJ>.
</CMP>
<FMP><OMOBJ> ... </OMOBJ></FMP>
</definition>
```

Definition of a monoid

A structure $(M, *, e)$ in which $(M, *)$ is a semi-group with unite is called a monoid.

How much semantic ?

- Semantic-web... machine process-able ?
- As much as authors like
    - from zero on
- Geared by features
- Offer them a feature...
- ...they will care for the data for it

OpenMath in action: Dynamic presentation
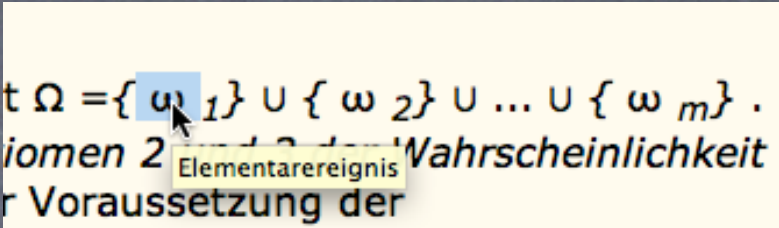
⇒   can offer interactivity

- symbol-name tool-tip

- click to browse to definition

- subterm-highlighting

⇒   content is presentation independent

- actually experienced

OpenMath in action: Copy and paste

- select sub-term in content

- paste in computer-algebra-systems interface

- works very restricted

- missing extension-capabilities of phrasebooks!

Authoring:
Current Workflow

- Write OMDoc source in jEdit

- but not OpenMath

  - use QMath syntax for formulae

- apply OQMath, reload and reference-check, test content presented

- test, check, and edit cycle

Authoring: Enjoyable ?

- kind-of...
- XML-editing isn't so bad
    - OMDoc content isn't so wild
    - jEdit offers large support with DTD
- cycling is enjoyable!
- authoring semantic math is hard

Authoring Semantic Math

- finding the right symbol
  - browse OM CDs and find the one
  - may be not fully satisfactory
    - need to define own symbol
    - need to extend presentation engines and input
- lacking overall practice
- textbooks are rich...
  - ... authors want this variety

Semantic Math Authoring: Lacking practice

- what's the semantic expression of:
- indexed sequences

    $(a_1 \ a_2 \ ... \ a_{k-1} \ a_{k+1} \ ... \ a_n)$

- sub-term labelling
  - very hard to layout!
  - authors make layout themselves
- structured rewrite
  - links between the parts being rewritten?

Currently available material

- some Abstract Algebra partly (CohenCuypers) en
- Analysis, (DahnWolter) plus new exercises de
- Statistik, Grabowski (HTWSaar) de
- Optimization, Izhutkin (Russia) ru,en
- MathePrisma, combinatorics (Wuppertal) de
- some Topology (Cairns) en
- Matheführerschein (Hussmann, Leuders) de
- Software Security, Hutter et al (SB, Bremen, München), en, de
- School Math: fractions (Kessler) de
-
- ...IUB courses (Kohlhase)
- ...moderate constructivist Calculus de, en (LeAM)

LeActiveMath FP6 project

Language-enhanced, user-adapative, interactive e-Learning for Mathematics

DFKI, Eurice, University of Edinburgh, University of Northumbria, TU Eindhoven, Universidad Malaga, Universität Augsburg, Ernst Klett Verlag, Universität des Saarlandes

European Commission

Information Society Technologies

Some goals of LeActiveMath

- Generic OpenMath-aware input editor
- Tutorial dialogues
- Database of interactive exercises
- OpenMath-aware computer-algebra system
- Several learning-effective tools
- Improved knowledge representation
- Web services
- Motivational and emotional diagnosis and reaction
- Improved open student modeling and tools
- Moderate constructivist calculus courses, school/univ
- Classroom tests

ActiveMath Roadmap

- Applied research directions:
    - Extend to other domains
    - Flexible exercise architecture
    - Efficient for 100 students
    - Privacy Issues
    - Authoring tools

ActiveMath Roadmap

- Basic research directions:
  - learning from errors
  - exercise generation
  - meta-reasoning
  - innovative course-generation
  - intelligent-support in authoring
  - knowledge representation and ontologies