

Annotating Rhetorical and Argumentative Structures in Mathematical Knowledge

Summary of my work at DERI (Apr–Oct 2008)
EECS Seminar

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KWARC – Knowledge Adaptation and Reasoning for Content

October 14, 2008

My Home: Mathematical Knowledge Management

- Ph. D. student with Prof. Michael Kohlhase
- Our group does “Mathematical Knowledge Management”
 - dealing with mathematical knowledge
 - formality ranges from human-friendly to computer-verifiable

My Project

- Collaboration on semiformal knowledge
- Using semantic web technologies (a semantic wiki, in particular)

What I Wanted to Learn About the Semantic Web

- engineering ontologies for scientific documents
- user interfaces for annotating and browsing
- relation of social interaction to knowledge

Where?

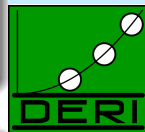
At DERI, they do this (and more)

DERI (Digital Enterprise Research Institute)

Largest semantic web research institute worldwide (130 members)

Applied Research

- eLearning
- semantic reality (sensor networks, ubiquitous computing)
- web services
- industrial applications
- *Semantic Information Systems and Language Engineering*
- *Social Software*



Foundational Research

- data intensive infrastructures
- information mining and retrieval
- reasoning and querying



SmILE



Before: SWiM, a Semantic Wiki for Mathematics



User

- User Page (Administrator)
- Preferences
- Logout
- Theme: [tundra] [soria]

Navigation

- IkeWiki Help
- Recent Changes

Search

Go Search

Edit

- Create Resource
- Create Class
- Create Property
- Create Multimedia
- Create Template
- Delete Resource
- Add Relation
- Remove Relation

System

- Manage Action Sets
- Manage Users
- Manage Roles
- Manage Namespaces
- Flush Caches
- Rebuild Index
- Restart System

Tools

- Export
- Import
- Print View
- Permalink
- Refresh

Article **arithmetic** Discussion Metadata Context Edit Annotate History

Identifier: `cd:arith`

Types: `omo:ContentDictionary` `omo:ContentDictionaryU` `omo:SignatureDictionary` `omo:ContentDictionaryU` `omo:ContentDictionaryGroup` `omo:OpenMathConcept` `rdf:Resource`

CD Base:
<http://www.openmath.org/cd>

Date:
2008-10-02

Version:
3

Review Date:
2006-03-30

Status:
draft

This CD defines symbols for common arithmetic functions.

Symbol Definition (lcm) [\[open this\]](#)

Role:
application

Title:
Least Common Multiple

Description:
This n-ary operator is used to construct an expression which represents the least common multiple of its arguments. If no argument is provided, the lcm is 1. If one argument is provided, the lcm is that argument. The least common multiple of x and 1 is x.

Pragmatic MathML:
<lcm/> [\[open this\]](#)

type : MathMLType

Property: [\[open this\]](#)
lcm(a,b) = a*b/gcd(a,b)

XML (OpenMath)
Content MathML
Prefix form
Presentation MathML

$$\text{lcm}(a, b) = \frac{|ab|}{\text{gcd}(a, b)}$$

Property: [\[open this\]](#)
for all integers a,b | There does not exist a c>0 such that c/a is an Integer and c/b is an Integer and lcm(a,b) > c.

XML (OpenMath)
Content MathML
Prefix form
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$$\forall a, b (a \in \mathbb{Z} \wedge b \in \mathbb{Z} \Rightarrow \neg \exists c. c > 0 \wedge a|c \wedge b|c \wedge c < \text{lcm}(a, b))$$

References

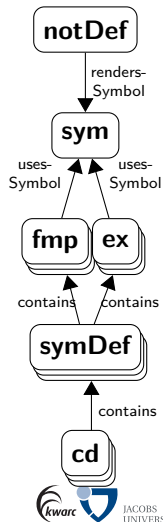
- outgoing
 - has author
 - has Discussion
 - Forum-13c81367490
 - contains SymbolDefinition
 - arith+abs
 - arith+big god
 - arith+big lcm
 - arith+divide
 - arith+gcd
 - arith+lcm
 - arith+minus
 - arith+plus
 - arith+power
 - arith+product
 - arith+root
 - arith+sum
 - arith+times
 - arith+unary minus
 - hasPart
 - type
 - ContentDictionary
 - OpenMathConcept
 - Resource
 - incoming
 - urtyped
- Socialise
- Digg this
 - Post to del.icio.us
 - Post to Furl
 - Post to Magnolia
 - Post to Yahoo
 - Permalink

Ontologies for Mathematical Documents (1)

Previous State

I had a basic ontology that modelled structures of mathematical knowledge; mainly *statements* (definition, theorem, proof, examples)

- used in SWiM for navigation, queries, internal bookkeeping



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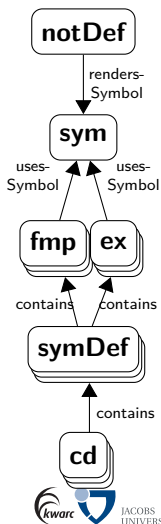
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Next Challenge

- Semi-formal knowledge often comes in *documents* that also contain *text*
- There is a document structure (chapter, section, cross-reference), and a rhetorical structure, both of which can be independent from the mathematical structure.



Ontologies for Mathematical Documents (2)

Getting the Model Right

document ont. \leftrightarrow annotation ont. \leftrightarrow $\left\{ \begin{array}{l} \text{rhetorical ont.} \\ \text{mathematical ont.} \end{array} \right.$

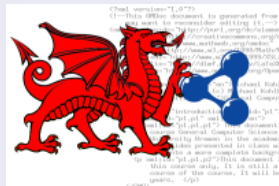
(following the SALT approach)

SALT (Semantically Annotated L^AT_EX)

semantic authoring framework for creating scientific publications

Implementation

- Expansion of the ontology
- Rules for extracting these concepts from OMDoc documents to RDF
- \rightsquigarrow Krexor XML \rightarrow RDF extraction library



User Interfaces for Annotating and Browsing

Improved Annotation Support

More and easier annotation support in the editor

- toolbars for easy selection of types of mathematical knowledge
- from phrase to theory level
- deleting annotations
- auto-completion of link targets (prepared)

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Rhetorical Annotation and Visualisation

- improved and extended syntax for annotating SALT-/RST-like rhetorical structures in OMDoc
using the SALT ontology within the host language OMDoc, not \LaTeX
- ideas for an editing interface
- visualisation of rhetorical relations and blocks implemented
→ *active documents*

Annotation

The screenshot shows a rich text editor with a toolbar at the top. Below the toolbar, there are three distinct sections of text, each enclosed in a dashed border. Each section has a header row with two columns: 'omtext' and 'type'. The first section is an introduction, the second is a contribution, and the third is a scenario. The text in the second section includes the mathematical formula $c^2 = a^2 + b^2$.

omtext	type=Introduction
In mathematics, the Pythagorean theorem is a relation in Euclidean geometry among the three sides of a right triangle. The theorem is named after the Greek mathematician Pythagoras, who by tradition is credited with its discovery and proof, although knowledge of the theorem almost certainly predates him.	
omgroup	type=contribution
The theorem is as follow:	
omtext	type=theorem
In any right triangle, the area of the square whose side is the hypotenuse is equal to the sum of the areas of the squares whose sides are the two legs or more formally $c^2 = a^2 + b^2$	
omtext	type=scenario
One of the consequences of the Pythagorean theorem is that irrational numbers, such as the square root of 2, can be constructed.	

Path: table.omdoc = tbody = tr = td

Sections in the editor

Annotation

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Mathematical Elements

Delete Table Start Autocompletion Set Text

General: generic element Document Structure ▾

OMDoc: Theories ▾ Formal Statements ▾ Informal Statements ▾ Text ▾

Mathematica Constitutive Statements ▾ Action
Nonconstitutive Statements ▾ Definition
Symbol

OpenMath: Content Dictionaries ▾ Signature Dictionaries ▾ CD Groups ▾

MathML: Notation Definitions ▾

The toolbar

Sections in the editor (Implementation by Gordan Ristovski)

Visualisation of Rhetorical Structures

test

Written by: hf

Date: 2001-12-12

motivation

This is random text While some scientists say the Moon is made of stone we prove that it is made of white cheese swiss Emmental cheese to be exact!

scenario

It was a nice sunny weekend I am preparing you for: This is a very important sentence! To conclude...

Rhetorical Blocks (SALT)

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Plain

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Remove Highlights

All Satellites

Antithesis

Elaboration

Rhetorical Relations (SALT, implementing RST)

(Implementation by Jana Giceva)

Argumentation about Mathematical Knowledge

Idea

Need for structured wiki discussions, well-defined workflow for solving problems with knowledge in a wiki

My Case

- a wiki page is an item of mathematical knowledge, e. g. a theorem
- issues discussed will be quite specific: e. g. “This theorem is hard to understand” (or wrong, or inadequately presented, . . .)

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Related Topic

There is also argumentation *within* artifacts of scientific knowledge, but so far I focused more on argumentation *about* them.

[Resource](#)[Edit](#)[Discussion](#)[History](#)

Resource

Edit

Discussion

History

Issue

Alice

2008-05-30

[Idea][Argument][Agree][Disagree][Decision]

It's hard to find out how to improve content (= resources) in [wikis](#) ☹️

Resource

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Discussion

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Issue Alice 2008-05-30 [Idea][Argument][Agree][Disagree][Decision]It's hard to find out how to improve content (= resources) in [wikis](#) ☹**Agree** Bob 2008-05-31

Indeed, besides automated approaches it's hard to get focused feedback from users.

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Argument Dave 2008-06-02 [Agree][Disagree]

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Agree Anonymous 2008-06-04

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Decision Christoph 2008-06-05

So let's do it! (Available in [SWiM](#))

Domain-Specific Argumentation

Assumptions

- Possible problems depend on the type of knowledge item
- Possible solutions depend on the type of knowledge item *and* the type of problem
- Standard problems have standard solutions, with which software can assist

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Survey (tinyurl.com/5qdetd)

- Common issues: wrong, incomprehensible, uncommon style, underspecified, redundant, truth uncertain
- Common solutions: directly improve affected knowledge item, split it
- When issues remain unresolved, it's mostly due to insufficient restructuring support

Domain-Specific Argumentation (Example)

Article Discuss Metadata Context Edit Annotate History

Issue/Incomprehensible Alice
Wed, 14 May 2008 18:00:24 +0100

I don't understand anything. How can this be applied?

Idea Decision

Idea/ProvideExample Bob
Wed, 14 May 2008 18:00:42 +0100

I'd suggest to provide an example that applies this theorem in a concrete domain.

Agree Disagree Decision

We don't need this. Cecil
Wed, 14 May 2008 19:02:18 +0100

Reply

Great Idea! Let's do that. Dan
Wed, 14 May 2008 19:01:52 +0100

Reply

New Issue New Comment

User Interface

Domain-Specific Argumentation (Example)

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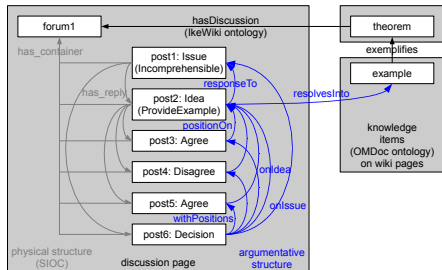
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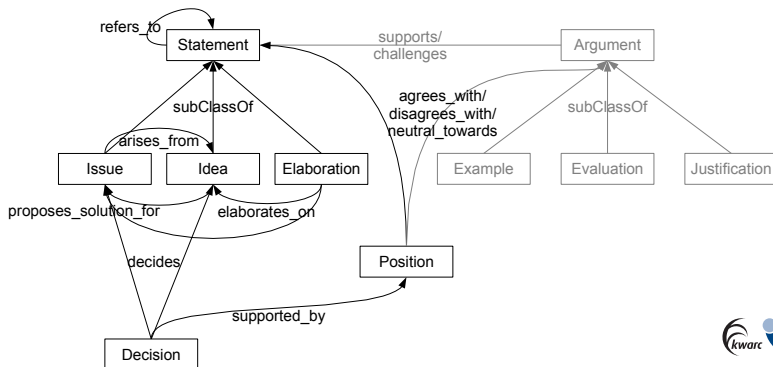
User Interface



RDF Graph

General Argumentation on Social Media Sites

- developing an argumentation module for SIOC (ontology for Semantically Interlinking Online Communities)
- joint work with Uldis Bojārs (SIOC) and Tudor Groza (SALT)
- use cases, model, guidelines for usage
- implementation and evaluation to be done



OpenMath Case Study

- lightweight mathematical ontology engineering (<http://wiki.openmath.org>)
 - no rhetorical structures, no documents
 - but still a lot of structures to annotate!
 - definitions, formal properties, examples, notations
 - local argumentation
- small group of knowledge engineers (domain experts)
- specialised editors: structured definitions, formulas, metadata
- evaluation needed

Summary

What I hope(d) to learn – to use it for mathematical knowledge management:

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What I hope to contribute to the semantic web:

- mathematics as a complex use case pointing out limits of the semantic web
- an ontology for a complex domain, with document structure, mathematical structure, and rhetorical structure
- domain-specific argumentation

Further Work

Active Documents

Interactive editing and previewing of notations

Further Work

Active Documents

Interactive editing and previewing of notations

Argumentation

Study relationship between argumentation within and about documents

Further Work

Active Documents

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Ontologies

- 1 Scalable metadata syntax and semantics for OMDoc
→ import metadata vocabularies as theories
- 2 Document these vocabularies in OMDoc
- 3 Model them in OMDoc
- 4 Export them back to the semantic web

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Semantic Web Empowering MKM