

EACA 2012

XIII Encuentro de Álgebra Computacional y Aplicaciones  
13-15 June, Alcalá de Henares

***Toward Multilingual Mechanized  
Mathematics Assistants***

JORDI SALUDES & SEBASTIAN XAMBÓ

UNIVERSITAT POLITÈCNICA DE CATALUNYA

# Abstract

The aim of this note is to present recent work in the area of **Multilingual Mechanized Mathematics Assistants**.

We will describe some of the key **features** expected from such systems, sketch some of the strategies envisioned for their **realization** and report on the current state of the **Mathematical Grammar Library**.

# Main points

- Contexts
- Word problems
- MGL
- Ancillary SMs
- gfsage
- Conclusions and further work
- References

# Contexts

Increasing role of computational methods

EACA-2012

- Effective Methods in Algebra, Analysis, Geometry and Topology.
- Algorithmic Complexity.
- Scientific Computation by means of Symbolic-Numerical Methods.
- Symbolic-Numeric Software Development.
- Analysis, Specification, Design and Implementation of SCS
- Applications to Science and Technology.

Multidisciplinarity

Mathematical Knowledge Management (QED manifesto)

Theorem provers

Mechanized Mathematical Assistants (Calculemus-07, MKM-07)

Educational needs

## Word problems

In a family party, uncle Tom asks Alice how old she is.

The day before yesterday I was 15, said Alice, and next year I will be 18.

What day is Alice's birthday?

Prominent role in learning mathematical modeling and reasoning.

Most of the relevant information is given as a natural language text.

Crucial skills needed:

- Translation of sentences into mathematical expressions

- Reasoning with those expressions

- Checking solutions

Difficulties

- Key terms, facts and relations may not be explicitly indicated.

  - yesterday, day before, year, this year, next year, age.

- Common knowledge about the terms is required.

- There are terms, facts and relations that are irrelevant.

  - family, family party, uncle, uncle Tom

# MGL

Modular library programmed in GF

GF

Based on functional programming and type theory

Abstract grammars (formal/computational semantics)

Concrete grammars (multilingual parsing/rendering)

Demo: **mathbar**

Historical

WebALT

language-independent mathematical didactical material

mOItto (<http://www.molto-project.eu/>)

to develop a set of tools for translating texts between multiple languages  
in real time with high quality.

## Example

```
abstract Arith = { // semantic structure of application domain
  cat
    Nat, Prop ; // types

  fun // constructor signatures
    Zero : Nat ;
    Succ : Nat -> Nat ;
    Even, Prime : Nat -> Prop ;
    Not : Prop -> Prop ;
    And, Or : Prop -> Prop -> Prop ;
}
```

How to get MGL

Publicly available using subversion as

```
svn co svn://molto-project.eu/mgl
```

A stable version can be found at

```
svn co svn://molto-project.eu/tags/D6.1
```



# Ancillary SMs

SM (Symbolic machine)

CAS

ATP

...



# gfsage

Sage commands in natural language (input and output)



GF Cats: **Command**, **Answer**.

Compute:

$\text{Kind} \rightarrow \text{Value} \text{ Kind} \rightarrow \text{Command}$

Simple answer:

$k \in \text{Kind} \rightarrow \text{Value } k \rightarrow \text{Answer}$

“it is 5”

Feedback answer:

$k \in \text{Kind} \rightarrow \text{Value } k \rightarrow \text{Value } k \rightarrow \text{Answer}$

“the factorial of 3 is 6”

Assume:

$\text{Prop} \rightarrow \text{Command}$

“I assume that x is greater than 2”

Assign:

$k \in \text{Kind} \rightarrow \text{Var } k \rightarrow \text{Value } k \rightarrow \text{Command}$

## Example

```
sage> compute the integral of the function mapping x  
to the square root of x on the closed interval  
from 1 to 2.
```

```
waiting...
```

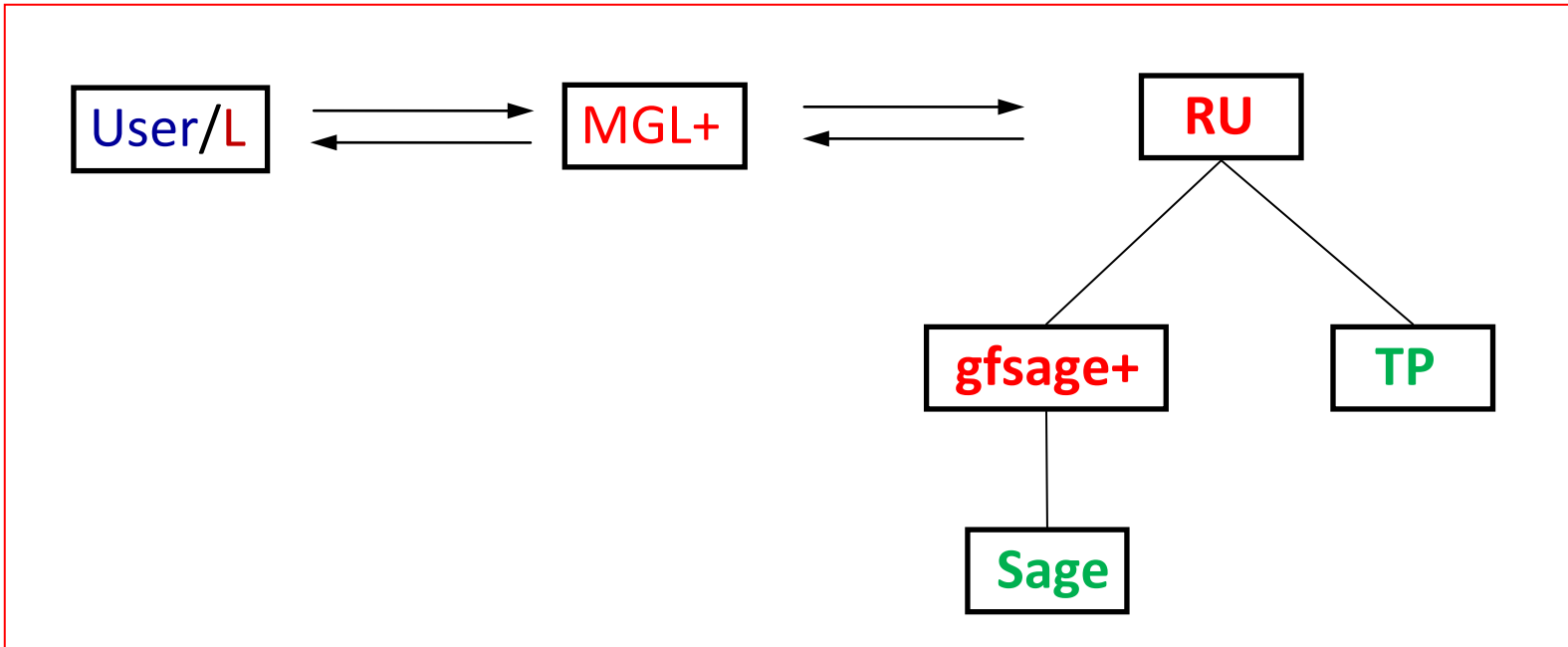
```
[4] 4/3*sqrt(2) - 2/3
```

[http://www.molto-project.eu/wiki/living-deliverables/  
d62-prototype-comanding-cas/gfsage-natural-language-interface-sage](http://www.molto-project.eu/wiki/living-deliverables/d62-prototype-comanding-cas/gfsage-natural-language-interface-sage)

→ <http://www.molto-project.eu/>

## Conclusions and further work

### *Dialog system*



MGL+ Fully functional MGL

RU Reasoning Unit

gfsage+ Fully functional gfsage

TP Theorem Prover

## References

- A. Ranta: *Grammatical Framework: Programming with Multilingual Grammars*. CLSI Publications. Stanford, 2011.
- J. Saludes and SX: *The GF Mathematics Library*. In: Proceedings of THEDU'11 (Wroclaw, Poland, 31<sup>st</sup> July 2011), First Workshop on CTP Components for Educational Software (edited by P. Quaresma & R.-J. Black). EPTCS **79**, 102-110 (2012).
- T. Hallgren, J. Saludes: *Math Bar Online*  
<http://www.grammaticalframework.org/demos/minibar/mathbar.html>
- D. Wayne: *How to solve word problems in mathematics*. McGraw-Hill, 2001.
- SX, H. Bass, G. Bolaños, R. Seiler, M. Seppälä: *e-Learning Mathematics*. In: Proceedings of the ICM-2006, Volume III, 1743-1768. EMS, 2006.
- SX, O. Caprotti and M. Seppälä: *Toward autonomous learners of mathematics*. In: E. M. Rocha, J. M. Borwein, J. F. Rodrigues (editors), *Communicating Mathematics in the Age of Digital Libraries*, 239-252. A. K. Peters, 2008.

*... se engendró en una cárcel, donde toda incomodidad tiene su asiento y donde todo triste ruido hace su habitación ...*



**¡Muchas gracias!**

**Thank you!**