

Sage: an open source mathematics software for Scientific Grid

Serge A. Salamanka



BalticGrid-II
2nd All Hands Meeting

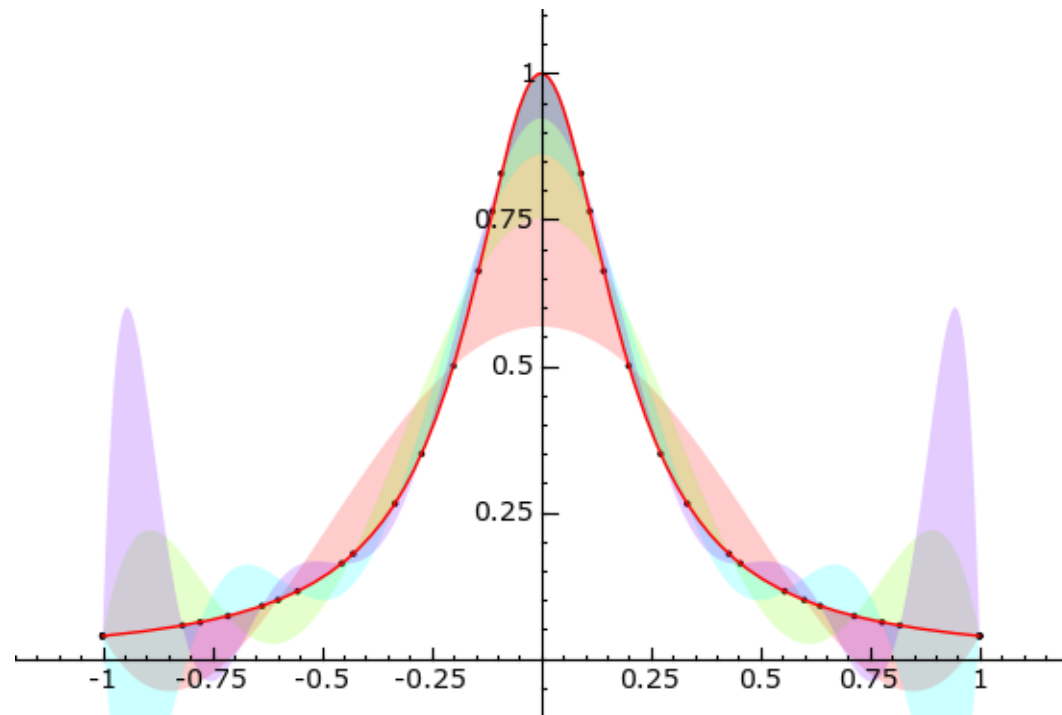
Riga, Latvia
12-14 May, 2009

Outline



- **Sage: A Computer Algebra System**
- **Sage: A Bridge Between Different Tools**
- **Sage: A Gateway To Scientific Grid Mathematics**

A Computer Algebra System



<http://sagemath.org/>

Sage is a free open source mathematics software system licensed under GPL. It combines the power of many existing open source packages into a common Python-based framework.

Mission:

Creating a viable free open source alternative to Magma, Maple, Mathematica and Matlab.

Why do we need an alternative ?

“Neub”ser’s Law”

“You can read [some] Theorem and its proof in [some] book in the library [. . .] then you can use [that] Theorem for the rest of your life free of charge, but for many computer algebra systems license fees have to be paid regularly [...]. You press buttons and you get answers in the same way as you get the bright pictures from your television set but you cannot control how they were made in either case.

With this situation **two of the most basic rules of conduct in mathematics are violated**: In mathematics **information is passed on free of charge** and **everything is laid open for checking**. Not applying these rules to computer algebra systems that are made for mathematical research [. . .] means **moving in a most undesirable direction**. Most important: Can we expect somebody to believe a result of a program that he is not allowed to see?” - J. Neub”ser (1993) (he started GAP in 1986).

Why do we need a free open source alternative ?

Maple, Mathematica and Matlab > 1000 \$

Distributed functionality will cost you even more !

Why do we need it to be a viable system ?

Implement a framework for constructing a universal and comprehensive mathematical software package.

Viable means active community, support, constant development ...

Viable also means that the programming language is kept alive: with Python it is very easy, noting that many Grid middleware components are implemented in Python.

Mission statement

Mess with the Best

Provide an open source, high-quality, and free viable alternative to **Magma**, **Mathematica**, **Maple** and **MATLAB**.

In other words: create a unified mathematics software package for algebra, calculus, elementary to very advanced number theory, cryptography, numerical computation, commutative algebra, group theory, combinatorics, graph theory, exact linear algebra and more.

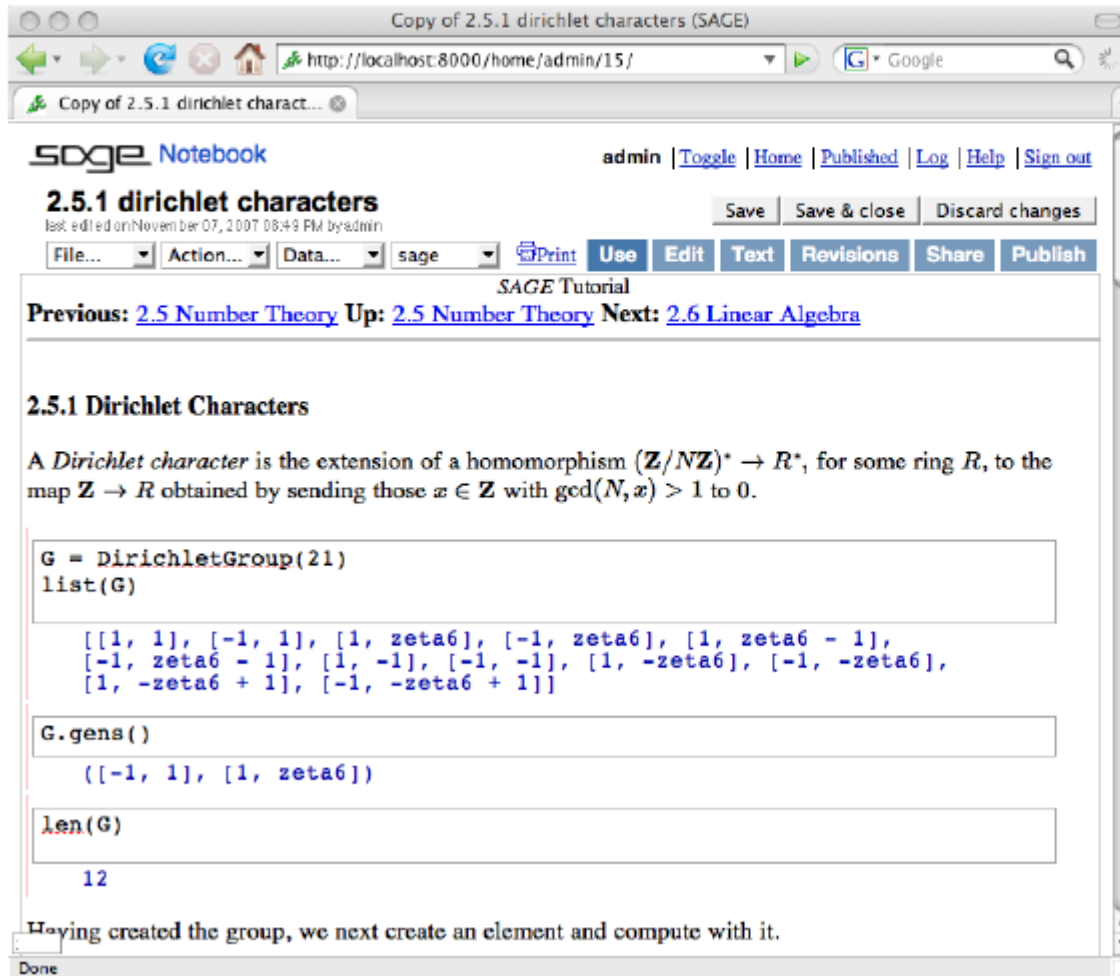
Features

Sage can be used to study general and advanced, pure and applied mathematics. This includes a huge range of mathematics, including algebra, calculus, elementary to very advanced number theory, cryptography, numerical computation, commutative algebra, group theory, combinatorics, graph theory, exact linear algebra and much more. It combines various software packages and seamlessly integrates their functionality into a common experience. It is well suited for education, studying and research.

The interface is a notebook in a web-browser or the command-line. Using the notebook, Sage connects either locally to your own Sage installation or to a Sage server on the network. Inside the Sage notebook you can create embedded graphics, beautifully typeset mathematical expressions, add and delete input, and share your work across the network.

Web-based Notebook Interface

public notebooks available at <http://www.sagenb.org>



The screenshot shows a web browser window titled "Copy of 2.5.1 dirichlet characters (SAGE)". The address bar shows "http://localhost:8000/home/admin/15/". The page header includes "SAGE Notebook" and navigation links for "admin", "Toggle", "Home", "Published", "Log", "Help", and "Sign out". The main content area is titled "2.5.1 dirichlet characters" and includes a "SAGE Tutorial" section. The tutorial text describes Dirichlet characters as an extension of a homomorphism $(\mathbf{Z}/N\mathbf{Z})^* \rightarrow R^*$. Below the text, there are three code input boxes with the following SAGE code and output:

```
G = DirichletGroup(21)
list(G)

[[1, 1], [-1, 1], [1, zeta6], [-1, zeta6], [1, zeta6 - 1],
[-1, zeta6 - 1], [1, -1], [-1, -1], [1, -zeta6], [-1, -zeta6],
[1, -zeta6 + 1], [-1, -zeta6 + 1]]

G.gens()

[[-1, 1], [1, zeta6]]

len(G)

12
```

Below the code, there is a text input field with the instruction: "Having created the group, we next create an element and compute with it."

- graphical user interface
- 2D plotting
- interactive 3D plotting
- \LaTeX typesetting
- web service (AJAX, SSL) inspired by Google Docs
- worksheet sharing
- worksheet up-/download

GHOP (SAGE) Notebook

admin | [Toggle](#) | [Home](#) | [Published](#) | [Log](#) | [Help](#) | [Sign out](#)

Save Save & close Discard changes

File... Action... Data... sage

Print Use Edit Text Revisions Share Publish

```
var('x')
f = sin(x) + cos(x)*x^2 + sqrt(x)
ismath(f)
```

$$\sin(x) + x^2 \cdot \cos(x) + \sqrt{x}$$

```
ismath(diff(f, x))
```

$$-x^2 \cdot \sin(x) + 2 \cdot x \cdot \cos(x) + \cos(x) + \frac{1}{2 \cdot \sqrt{x}}$$

```
ismath(f.taylor(x, 0, 10))
```

$$\sqrt{x} + x + x^2 - \frac{x^3}{6} - \frac{x^4}{2} + \frac{x^5}{120} + \frac{x^6}{24} - \frac{x^7}{5040} - \frac{x^8}{720} + \frac{x^9}{362880} + \frac{x^{10}}{40320}$$

jsMath

Sage is a mathematics software package developed by a worldwide community of developers.

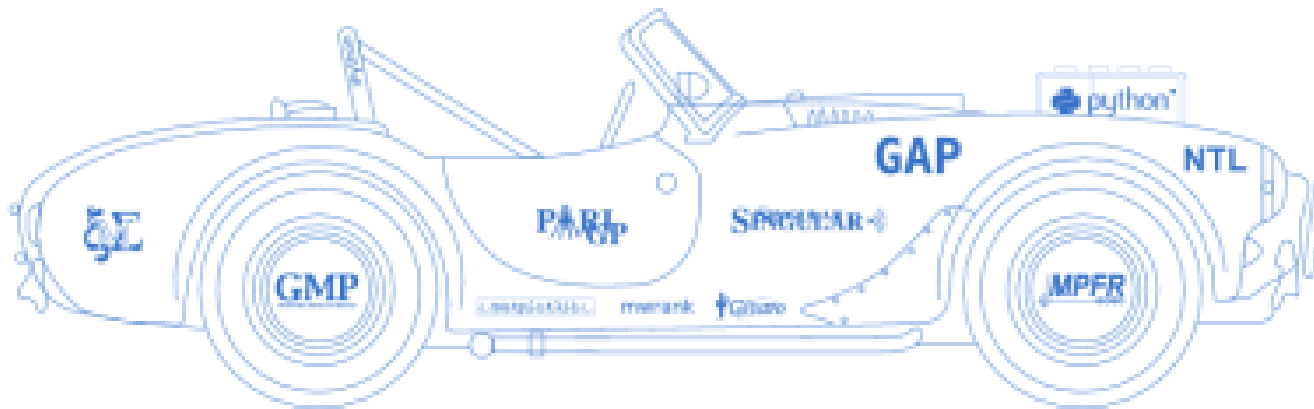
- 1. a distribution of the best free, open-source mathematics software,**
- 2. an interface to most free and commercial mathematics software packages,**
- 3. a new library, which uniformly covers the widest area of functionality.**

Try it yourself at <http://sagenb.org/>

A Bridge Between Different Tools

<http://www.sagemath.org/links-components.html>

SAGE
Building »The Car«



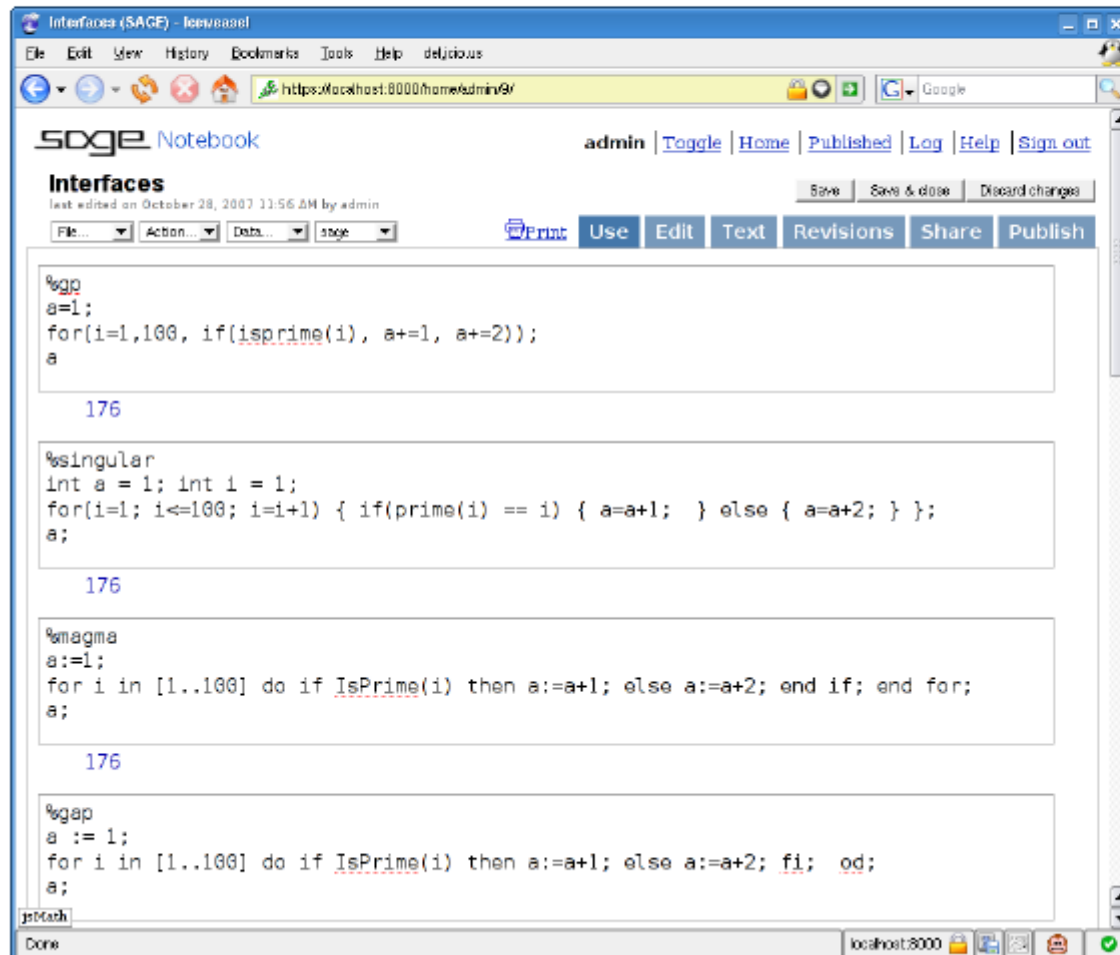
»Every free computer algebra system I've tried has
reinvented many times the wheel without being able to build the car.«

Distribution includes:

Arithmetic	GMP, MPFR, Givaro, MPFI
Commutative Algebra	PolyBoRi, SINGULAR (libSINGULAR)
Linear Algebra	LinBox, M4RI, IML, fpLLL
Cryptosystems	GnuTLS, PyCrypto
Integer Factorization	FlintQS, ECM
Group Theory	GAP
Combinatorics	Symmetrca, sage-combinat
Graph Theory	NetworkX
Number Theory	PARI, NTL, Flint, mwrnk, eclib
Numerical Computation	GSL, Numpy, Scipy, ATLAS
Calculus, Symbolic Comp.	Maxima, Sympy, Pynac
Statistics	R
User Interface	Sage Notebook, jsmath, Moin wiki, IPython
Graphics	Matplotlib, Tachyon, libgd, JMol
Networking	Twisted
Databases	ZODB, SQLite, SQLAlchemy , Python pickle
Programming Language	Python, Cython (compiled)

Overall more than 70 packages are included and shipped with **Sage**.

GUI for Many Mathematics Packages



```
Interfaces (SAGE) - localhost
File Edit View History Bookmarks Tools Help delicious
https://localhost:8000/home/admin9/
sage Notebook admin | Toggle | Home | Published | Log | Help | Sign out
Interfaces last edited on October 28, 2007 11:56 AM by admin
File... Action... Data... sage... Print Use Edit Text Revisions Share Publish
%pari
a:=1;
for(i=1,100, if(isprime(i), a+=1, a+=2));
a
176
%singular
int a = 1; int i = 1;
for(i=1; i<=100; i=i+1) { if(prime(i) == 1) { a=a+1; } else { a=a+2; } };
a;
176
%magma
a:=1;
for i in [1..100] do if IsPrime(i) then a:=a+1; else a:=a+2; end if; end for;
a;
176
%gap
a := 1;
for i in [1..100] do if IsPrime(i) then a:=a+1; else a:=a+2; fi; od;
a;
Done localhost:8000
```

Examples:

- Pari
- Maxima
- Singular
- Gap
- Mathematica
- Maple
- ...



Sage does not come with yet-another ad-hoc math language, it uses **Python** instead.

- one of the most widely used programming languages (Google, IML, YouTube, NASA),
- easy for you to define your own data types and methods on it (bitstreams, ciphers, rings, whatever),
- Very clean language that results in easy to read code,
- a **huge number of libraries**: statistics, networking, databases, bioinformatic, physics, video games, 3d graphics, numerical computation (scipy), and serious “pure” mathematics (via Sage)
- easy to use existing C/C++ libraries from Python (via **Cython**)

So,

Sage is an open source alternative for academic world.

Sage is a perfect bridge between different cutting edge tools from all around the world.

Sage has an active broad community.

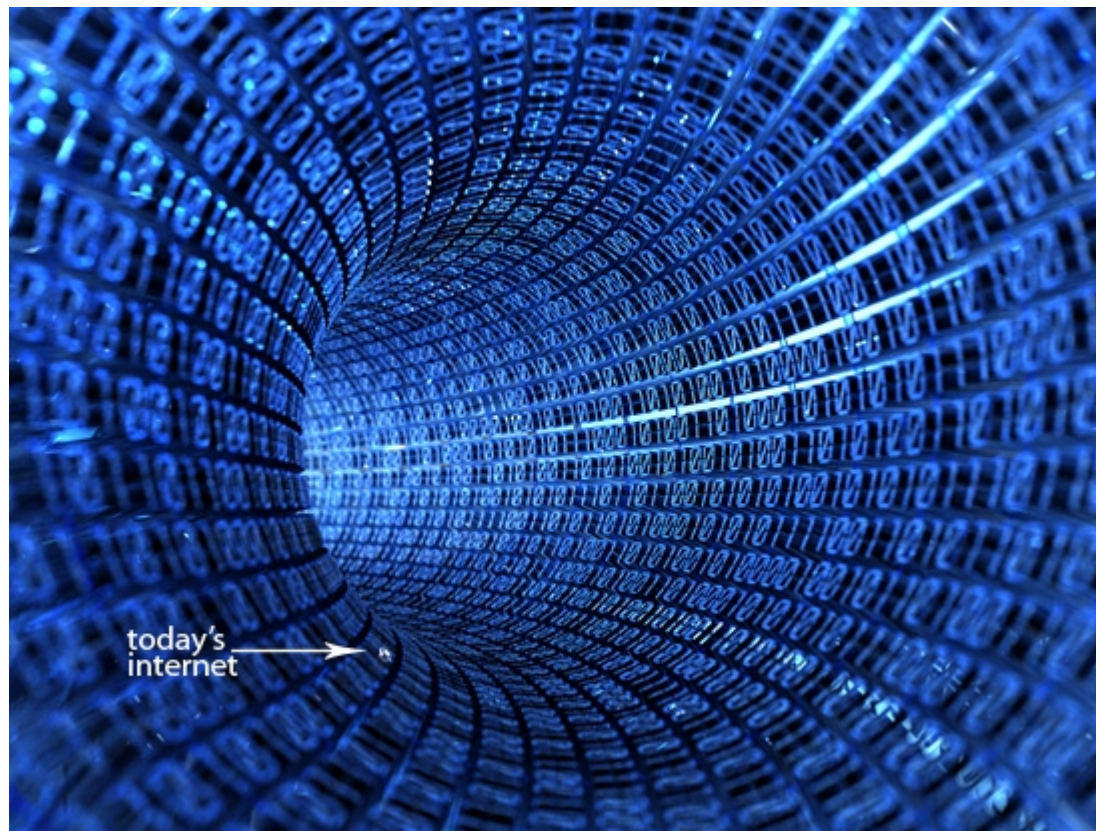
What can we make out of this ?

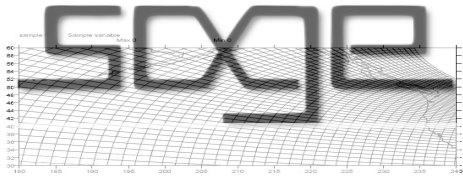
We can build a Sage World of Mathematics on Grid !



Let's see the roadmap...

A Gateway To Scientific Grid Mathematics





SAGE on Grid
is an opportunity that
excites my mind
and drives me to the frontier of
scientific research and
exploration of ideas.





SAGE on Grid
is an opportunity that
excites my mind
and drives me to the frontier of
scientific research and
exploration of ideas.



**Let's have a look at the tools we have for
gridification of Sage ...**

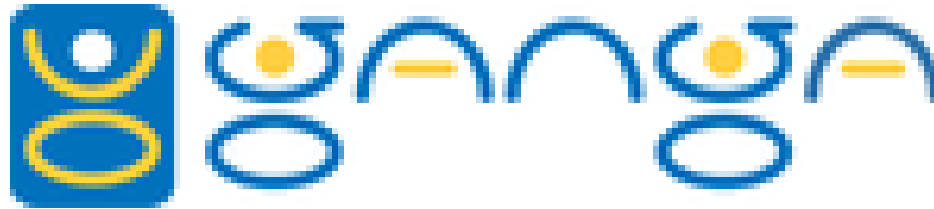


RESPECT

The RESPECT program (Recommended External Software for EGEE CommuniTies) aims to publicize grid software and services that work well in concert with the EGEE gLite software and thereby :

- * Expand the functionality of the grid infrastructure for users,
- * Reduce duplicated development when porting applications, and
- * Speed the porting of new application to the grid.

<http://technical.eu-egee.org/>



Ganga

Ganga is an easy-to-use frontend for job definition and management, implemented in **Python**. It has been developed to meet the needs of the ATLAS and LHCb. Ganga allows trivial switching between testing on a local batch system and large-scale processing on Grid resources. Ganga is readily extended and customised to meet the needs of different user communities.

Activities outside of ATLAS and LHCb where Ganga is successfully used include Geant4 regression tests and image classification for web-based searches, also many other projects.

<http://ganga.web.cern.ch/ganga/>



DIANE

DIANE is a lightweight job execution control framework for **parallel scientific applications**. DIANE improves the reliability and efficiency of job execution by providing **automatic load balancing, fine-grained scheduling** and **failure recovery**.

DIANE provides an environment in which the existing applications may be more easily ported to **heterogenous computing environments** such as the Grid, batch farms or interactive clusters.

The DIANE framework takes care of all synchronization, communication and workflow management details on behalf of the application.

<http://cern.ch/diane>

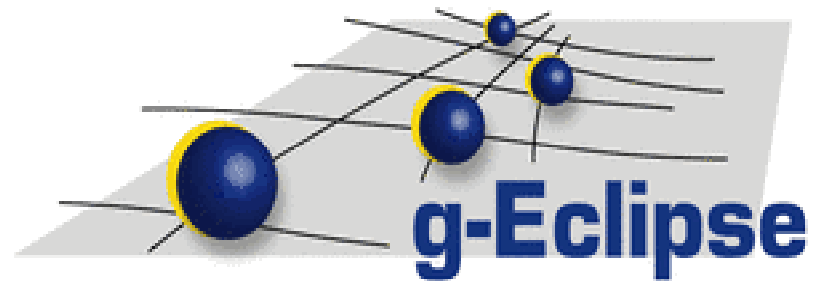


GUP - Institut für Graphische und Parallele Datenverarbeitung

i2glogin

i2glogin is a tool that enables interactive communication between a grid job and the user. The tool opens a fast, secure channel between the job and the user interface allowing, for example, debugging of the remote environment, application steering, or remote visualization.

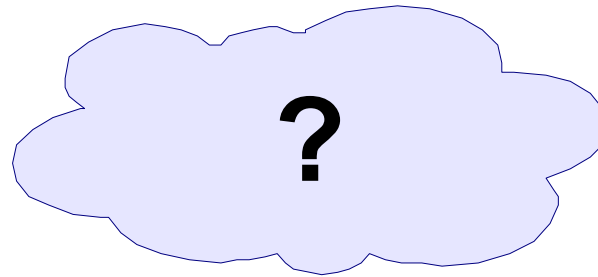
<http://www.gup.uni-linz.ac.at/i2glogin>



g-Eclipse - Access the power of the Grid

The g-Eclipse project aims to build an integrated workbench framework to access the power of existing Grid infrastructures. The framework will provide tools to customize Grid users' applications, to manage Grid resources and to support the development cycle of new Grid applications. Therefore, already existing tools (such as the Migrating Desktop, the GridBench suite, the Grid Visualisation Kernel (GVK), ...) will be integrated.

<http://geclipse.org/>



Subject for discussion

Disclaimer: I'm not a grid-application developer, I'm a grid-operator.

Subject:

The way and tools for gridification of Sage.

Board message:

I'd like to find interested and enthusiastic people to work with.

Suggestion:

Meet on the BalticGrid-II Summer School (June 29 - July 3, 2009) and have a more detailed discussion.

To express everything at once I should say that Sage could become the default mathematical software for scientists, ex. in HEP, if it fully utilizes Grid functionality.

I hope someday SAGE is going to replace "the-so-loved" Mathematica providing efficient and diverse algorithms that are used on the frontier of science.

To say more, SAGE Math Server could also become a collaboration platform for scientists doing mathematical computations.

We MUST have a universal and comprehensive math software package inside the borders of academics to unify research results and work on the same platform!

If this platform could be our UNICORE or gLite-based Grid then SAGE will be the best option for everyone involved in science.

Thank you !

**See my personal weblog
about gridification of SAGE at**

<http://sageworldmath.blogspot.com>

We can have a short discussion there in
comments section.

