Open Digital Research Environment Toolkit

for the Advancement of Mathematics

http://opendreamkit.org

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OpenDreamKit is a Horizon 2020 European Research Infrastructure project that will run for four years, starting from September 2015.

It provides substantial funding to the open source computational (pure) mathematics ecosystem, in particular popular tools such as **GAP**, **LinBox**, **MPIR**, **SageMath**, **Pari/GP**, **LMFDB**, **Singular**, **MathHub**, and the **Jupyter** interactive computing environment.

The success of these systems over the past decades bears witness to the power of collaborative open source development models, by users and for users, for delivering general purpose systems, targeting a large public (researchers, teachers, engineers, amateurs, etc).

We address some critical long term issues, in particular on the technical side, in order to boost the productivity and lower the entry barrier:

- Streamline access, distribution, portability on a wide range of platforms, including HPC and Cloud services.
- Improve user interfaces, in particular in the promising area of collaborative workspaces.
- Lower barriers between research communities and promote dissemination. For example, we want to make it easy for a specialist of scientific computing to use tools from pure mathematics, and vice versa; bring together the developers communities to promote tighter collaboration and symbiosis, accelerate joint development, and share best practices.
- Outsource as much of the development as possible to larger communities to focus on our core specialty: the implementation of mathematical algorithms and databases.

The project currently has 18 sites, and about 60 active researchers and software developers across Europe.

Maths in the Middle

Mathematics is the common language which should be used to interface mathematical software.

MMT (Meta-Meta-Theory, Meta-Meta-Tool) is a highly flexible formal system striking a balance between 'mathematical prose' and strict machine-checkable formalisation.

```
namespace http://mathhub.info/MitM/Groups

import fnd http://mathhub.info/MitM/Foundation
import smglom http://mathhub.info/MitM/smglom
import sets http://mathhub.info/MitM/smglom/sets

theory Group : fnd:?Logic =
  include ?monoid

  theory GroupTheory : fnd:?Logic =
    include ?monoid/monoid_theory

    inverse : U → U # 1 ⁻¹ prec 24
    inverse_property : ⊢ ∀ [x : U] x ∘ x ⁻¹ ≐ e

group = ModelsOf GroupTheory

include fnd:?NatLiterals

/T The number of elements of a group
order : group → ℕ+
```

Fig. 1: Group Theory in MMT

We use **MMT** to describe *semantic interfaces* to mathematical software packages, such as **GAP**, **Sage**, **Singular**, databases such as **LMFDB** or the ATLAS of Finite Groups, or databases of mathematical papers, such as the **arXiv**.

The open interoperability standard *Maths in the Middle* is built on these semantic descriptions, encoded in **OMDoc**, an extension to **OpenMath** and **MathML**, XML formats to represent mathematical knowledge.

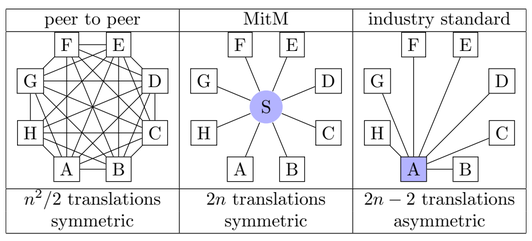


Fig. 2: Interfacing Strategies

This lowers workload for implementors of mathematical software, enabling access to a large pool of external resources.

Future plans include generating highly efficient interfaces with low computational overhead.

Maths in the Middle Usecases

- Search mathematical texts for formulæ *structurally*: searching for $x^2 + y^2 = z^2$ will also yield results containing $a^2 + b^2 = c^2$.
- Search **OEIS** for formulæ and sequences, creating objects in the CAS of choice to do further computation.
- Query **LMFDB** from **GAP** for a Galois group, yielding a **GAP** group object that can be used in computations, for example to find out whether it is soluble.
- Explore the knowledge contained in and structure of **GAP**: types, relations, code. This can be done online, or through **MMT**. We make use of this information in the development of **GAP**.

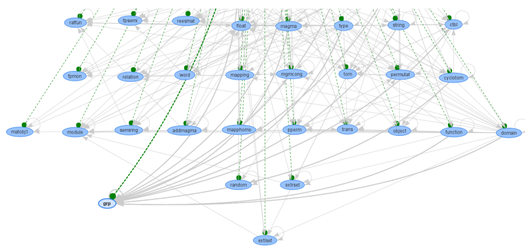


Fig. 3: GAP Theory Graph for **grp**

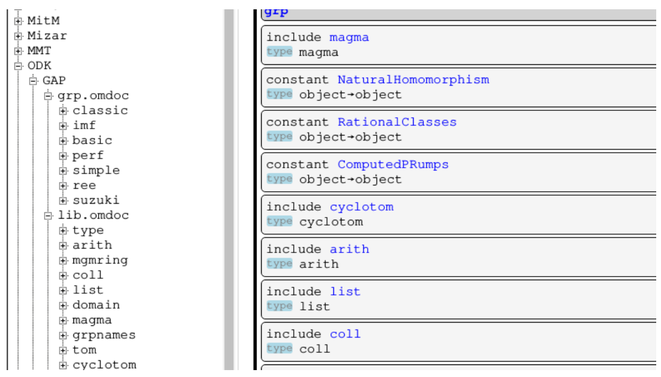


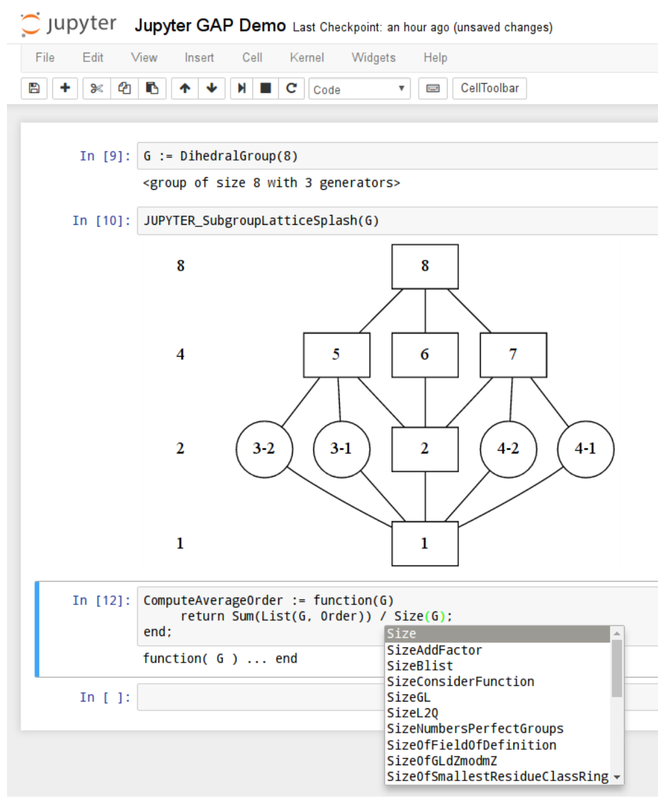
Fig. 4: Browsing the GAP Type Export

- Near future: Efficiently compute with group actions defined in **GAP** on polynomials defined in **Singular** through an automatically generated interface.
- *Your usecase here: What would you want to do with Maths in the Middle?*

User Interfaces: Jupyter

Formerly known as **IPython**, **Jupyter** is a tool for writing interactive documents backed by a large selection of software packages. **JupyterHub** and **JupyterLab** allow institutional installations. **Jupyter** has an excellent track record, an active community of contributors, and is backed by foundations and commercial entities.

We developed a **GAP** interface for **Jupyter**, providing a web-based GUI for **GAP**, lowering the barrier to use **GAP** in research and teaching.



This interface is available through **PyPI**, the **Python** package index, and can be obtained by executing **pip install jupyter-kernel-gap** on many systems. It has also been made part of **SageMath**, and deployed on the **CoCalc** platform.

We would like more users and contributors for this project and are looking forward to your input at **https://github.com/gap-packages/jupyter-kernel-gap**.

HPC-GAP

Implementing parallelised algorithms for *permutation groups* (Schreier-Sims, Backtrack Search), *matrix groups*, *semigroups* (Froidure-Pin enumeration), and *finitely presented groups* (proving hyperbolicity and isomorphism testing).

Links

http://opendreamkit.org contact@opendreamkit.org @OpenDreamKit https://github.com/OpenDreamKit

https://jupyter.org
http://www.gap-system.org
https://github.com/gap-system
https://github.com/gap-packages
https://www.singular.uni-kl.de/dox/html/
https://sagemath.org
https://cocalc.com
http://mathhub.info
http://mathhub.info/MitM
https://uniformal.github.io
https://openmath.github.io
https://lmfdb.org

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