
Software Citation, Landing Pages, and the swMATH Service

Wolfgang Dalitz, Helge Holzmann, Wolfram Sperber

FORCE2017, Berlin, 25-27 October 2017



Agenda

- Introduction (W. Sperber):
 - Why we have proposed this meeting?
 - Software Citations and the Software Citation Principles
 - Open problems
- swMATH: The publication based approach and swMATH landing pages (W. Dalitz)
- Live Demo: Software archiving and structurization (H. Holzmann)
- Discussion

Why this meeting?

- Increasing role of scientific (mathematical) software
Today, 'mathematical modeling and simulation' is an ubiquitous method in natural sciences and engineering and mathematical software is the tool to realize it.

But

- discovering (mathematical) software is difficult, an established infrastructure (standards and information services) for scientific (mathematical) software is missing
- less credit for (mathematical) software development
- reproducibility and evaluation of scientific results which were achieved by using scientific (mathematical) software is difficult.

Presentation and discussion of an alternative approach for maintaining mathematical software information

Software Citations in biology

Table 1 Varieties of software mentions in publications, from *Howison & Bullard (2015)*.

Mention type	Count (n = 286)	Percentage (%)
Cite to publication	105	37
Cite to user's manual	6	2
Cite to name or website	15	5
Instrument-like	53	19
URL in text	13	5
In-text name only	90	31
Not even name	4	1

and in mathematics (for the optimization software SCIP)

Mention Type	Count	Percentage
Cite to publication	84	46,67 %
Cite to user manual	2	1.11 %
Cite to website	19	10.56 %
Cite to other sources	3	1.67 %

The Software Citation Principles

- **Motivation:** citation of software container
- **SCP1. Importance:** Software is a legitimate and citable product of research [...]
- **SCP2. Credit and Attribution:** Software citations should facilitate giving scholarly credit and normative and legal attribution to all contributors to the software [...]
- **SCP3. Unique identification:** A software citation should include a method for identification that is machine actionable, globally unique, interoperable, [...]
- **SCP4. Persistence:** Unique identifiers and metadata describing the software and its disposition should persist [...]
- **SCP5. Accessibility:** Software citations should facilitate access to the software itself and to its associated metadata, documentation, data, and other materials necessary for both humans and machines [...]
- **SCP6. Specificity:** Software citations should facilitate identification of, and access to, the specific version of software that was used. [...]

Remarks

- The Software Citation Principles discuss not only citations but also metadata, persistence of software information, versions etc. They define a general framework for software information as a base for the development of
 - standards for software information (citations, metadata)
 - information services for persistent provision of information
- There is a broad spectrum of use cases for software with different requirements to information about software.

Some open problems for implementation (I)

- Citation standard
- Persistent identifiers (DOIs?)
- Persistent metadata for what? What are ,software products‘?
software products are sets of different kind of objects:
 - source code, binary file, service, etc.
 - software documentation
 - software developers
 - software licenses
 - ...
- Accessibility: persistent landing pages (metadata plus links)
Definition of metadata schemes (CodeMeta)

Some open problems for implementation (II)

- Archiving: persistence of links?
- What is with specificity? A lot of software objects are version-specific
 - high-dimensional metadata schemes for software (CodeMeta)
- Maintenance: Who should (could) maintain software information?
 - diverse developments
for mathematical software especially the swMATH/Tempas concept


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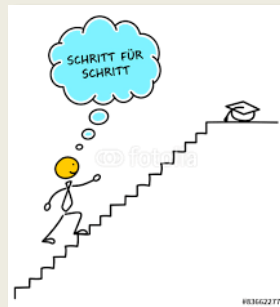
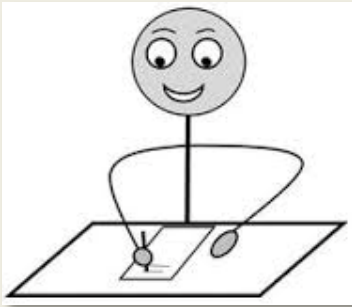
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Agenda

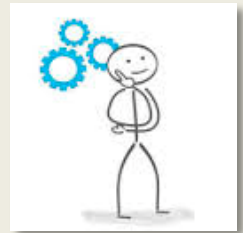
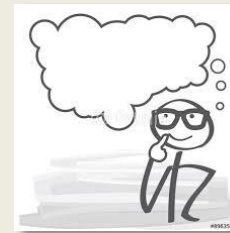
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Motivation: Scientific Workflow

Scientist



Software Developer



Scientific Software in Mathematics

Scientific Software

- plays an important role within the scientific workflow
- produces new scientific results
- is (sometimes) the base of a proof (e.g. four color problem/Vierfarbenproblem)
- is a creative process

Scientific Software Developer

- receives little or no scientific recognition
- gets no or less academic reputation
- gets no credit points in his academic career

Brigding the Gap: www.swmath.org

- make important software visible (and accesible)
 - don´t gather all what you can get
 - take care of quality
-
- main idea: publication based approach
 - cooperation with Zentralblatt MATH (zbMATH)

What is zbMATH?

zbMATH is a abstracting and reviewing service in pure and applied mathematics

- zbMATH database contains
 - 4 million bibliographic entries with reviews and abstracts
 - drawn from about 3,000 journals and serials and from
 - 180,000 books
- about 7,000 active reviewers from all over the world contribute reviews to zbMATH
- zbMATH covers all available published and peer-reviewed articles, books, conference proceedings as well as other publication formats
- all entries are classified according to the Mathematics Subject Classification Scheme (MSC2010)

Main Idea: Publication Based Approach

- The intention is to offer a list of all publications that refer to a software recorded in swMATH
- In particular, all articles are given, which are included in Zentralblatt MATH (zbMATH)
- Articles that describes the background and technical details of a program, as well as those publications in which a piece of software is applied or used for research

Shortly:

- Which articles refer/review software?
- Store the result into a database

Quick Overview: www.swmath.org



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18961 software packages with 240058 references in 141876 zbMATH-articles




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SCIP

SCIP is currently one of the fastest non-commercial solvers for mixed integer programming (MIP) and mixed integer nonlinear programming (MINLP). It is also a framework for constraint integer programming and branch-cut-and-price. It allows for total control of the solution process and the access of detailed information down to the guts of the solver. SCIP is part of the SCIP Optimization Suite, which also contains the LP solver SoPlex, the modelling language ZIMPL, the parallelization framework UG and the generic column generation solver GCG.


This software is also **peer reviewed** by journal MPC.

Keywords for this software



The word cloud contains the following terms: integer programming, constraint programming, global optimization, branch-and-bound, quadratic programming, combinatorial optimization, mixed integer programming, mixed integer nonlinear programming, column generation, integer linear programming, mixed-integer programming, polyhedral combinatorics, SAT, heuristics, non-convex optimization, and branch-and-cut.

URL: scip.zib.de/
InternetArchive

Versions:  [Info](#)

Authors: Gerald Gamrath, Ambros Gleixner, Gregor Hendel, Stephen J. Maher, Matthias Miltenberger, Benjamin Müller, Marc Pfetsch, Felipe Serrano, Dieter Weninger, Jakob Witzig

Platforms: Linux, Windows, Mac OS

Licence: ZIB academic license

Current version: 3.2

Dependencies: LP-solver, e.g. SoPlex, CPLEX, XPress, ...

[Add information on this software.](#)

Related software:

- CPLEX
- MIPLIB
- MIPLIB2003
- SoPlex
- Gurobi
- XPRESS
- MINLPLib
- LINDO
- Benchmarks for Optimization...
- FEASPUMP

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Example cont.

References in zbMATH (referenced in 237 articles , 4 standard articles)

Showing results 1 to 20 of 237.

Sorted by year (citations) 20

1 2 3 ... 10 11 12 next

- Andrea Callia D'Iddio, Michael Huth: Manyopt: An Extensible Tool for Mixed, Non-Linear Optimization Through SMT. Solving (2017) [arXiv](#)
2. Assarf, Benjamin; Gawrilow, Evgenij; Herr, Katrin; Joswig, Michael; Lorenz, Benjamin; Paffenholz, Andreas; Rehn, Thomas: Computing convex hulls and counting integer points with polymake (2017)
 3. Belotti, Pietro; Berthold, Timo: Three ideas for a feasibility pump for nonconvex MINLP (2017)
 4. Brinkmann, Philip; Ziegler, Günter M.: A flag vector of a 3-sphere that is not the flag vector of a 4-polytope (2017)
 5. Cussens, James; Järvisalo, Matti; Korhonen, Janne H.; Bartlett, Mark: Bayesian network structure learning with integer programming: polytopes, facets and complexity (2017)
 6. Gleixner, Ambros M.; Berthold, Timo; Müller, Benjamin; Weltge, Stefan: Three enhancements for optimization-based bound tightening (2017)
 7. Göttlich, Simone; Potschka, Andreas; Ziegler, Ute: Partial outer convexification for traffic light optimization in road networks (2017)
 8. Haws, David; Cussens, James; Studený, Milan: Polyhedral approaches to learning Bayesian networks (2017)
 9. Humpola, Jesco; Serrano, Felipe: Sufficient pruning conditions for MINLP in gas network design (2017)
 10. Ichim, Bogdan; Katthän, Lukas; Moyano-Fernández, Julio José: How to compute the Stanley depth of a module (2017)
 11. Khan, Kamil A.; Watson, Harry A.J.; Barton, Paul I.: Differentiable McCormick relaxations (2017)
 12. Lima, Ricardo M.; Grossmann, Ignacio E.: On the solution of nonconvex cardinality Boolean quadratic programming problems: a computational study (2017)
 13. Modaresi, Sina; Vielma, Juan Pablo: Convex hull of two quadratic or a conic quadratic and a quadratic inequality (2017)
 14. Newby, Eric; Ali, M.M.: Linear transformation based solution methods for non-convex mixed integer quadratic programs (2017)
 15. Pecin, Diego; Pessoa, Artur; Poggi, Marcus; Uchoa, Eduardo: Improved branch-cut-and-price for capacitated vehicle routing (2017)
 16. Pferschy, Ulrich; Staněk, Rostislav: Generating subtour elimination constraints for the TSP from pure integer solutions (2017)
 17. Puranik, Yash; Sahinidis, Nikolaos V.: Bounds tightening based on optimality conditions for nonconvex box-constrained optimization (2017)
 18. Witzig, Jakob; Berthold, Timo; Heinz, Stefan: Experiments with conflict analysis in mixed integer programming (2017)
 19. Andreatta, G.; Casula, M.; De Francesco, C.; De Giovanni, L.: A branch-and-price based heuristic for the stochastic vehicle routing problem with hard time windows (2016)
 20. Berthold, Timo; Farmer, James; Heinz, Stefan; Perregaard, Michael: Parallelization of the FICO Xpress-Optimizer (2016)

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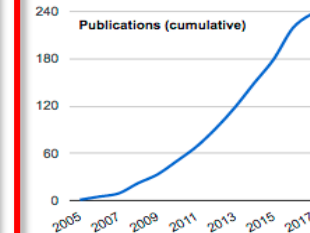
MSC classification / top

- Top MSC classes
 - 05 Combinatorics
 - 52 Convex and discrete...
 - 65 Numerical analysis
 - 68 Computer science
 - 90 Optimization
- Other MSC classes

Publication year

- 2010 - today
- 2005 - 2009
- 2000 - 2004
- before 2000

Chart: cumulative / absolute



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- browse software by MSC
- browse software by types

Results 1 to 20 of 18961

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z all

01poly Referenced in 8 articles [sw14281]

Remote computing services via e-mail. 0/1-Polytopes. By sending an e-mail to cggg@ist.tugraz.at with the following body: 01poly [OPTIONS] you get information about 01-polytopes of dimension ...

1000Minds Referenced in 1 article [sw16167]

1000Minds is an online suite of tools and processes to help individuals and groups make decisions and also for understanding other people's choices. 1000Minds has ...

13cflux2 Referenced in 2 articles [sw11825]

Metabolic fluxes are the final endpoint of all co-operating actions in the complex cellular network of genes, transcripts, proteins and metabolites. In vivo fluxes, however, ...

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- 2 Book Companion Software (50)
- 3 Data Collections (30)
- 4 Languages (133)
- 5 Educational (32)
- 6 Portals (16)
- 7 Services, Webservices (17)

special collections:

- 1 Math.Modeling and Simulation - MMS (24)
- 2 Theorem Prover Museum (22)

Browse software by Mathematics Subject Classification (MSC 2010)

- | | |
|--------------------------------------------------|-------------------------------------------------------------|
| 00 General mathematics | 46 Functional analysis |
| 01 History; biography | 47 Operator theory |
| 03 Mathematical logic | 49 Calculus of variations and optimal control; optimization |
| 05 Combinatorics | 51 Geometry |
| 06 Ordered structures | 52 Convex and discrete geometry |
| 08 General algebraic systems | 53 Differential geometry |
| 11 Number theory | 54 General topology |
| 12 Field theory and polynomials | 55 Algebraic topology |
| 13 Commutative algebra | 57 Manifolds and cell complexes |
| 14 Algebraic geometry | 58 Global analysis, analysis on manifolds |
| 15 Linear and multilinear algebra; matrix theory | 60 Probability theory and stochastic processes |
| 16 Associative rings and algebras | 62 Statistics |
| 17 Nonassociative rings and algebras | 65 Numerical analysis |
| 18 Category theory, homological algebra | 68 Computer science |
| 19 K-theory | 70 Mechanics of particles and systems |
| 20 Group theory and generalizations | 74 Mechanics of deformable solids |
| 22 Topological groups, Lie groups | 76 Fluid mechanics |
| 26 Real functions | 78 Optics, electromagnetic theory |
| 28 Measure and integration | 80 Classical thermodynamics, heat transfer |
| 30 Functions of a complex variable | |

Browse software by keywords

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

- | | | |
|-------------------------------|--------------------------------|--------------------------------|
| A | G | P |
| a posteriori error estimation | Galerkin method | parallel algorithms |
| accuracy | game theory | parallel computing |
| adaptive mesh refinement | Gaussian elimination | parallel processing |
| adaptivity | geometry | parallel programming |
| algebraic geometry | geophysics | parallelization |
| algebraic multigrid | general relativity | parameter estimation |
| algebraic specification | generalized eigenvalue problem | partial differential equations |
| algebraic topology | generic programming | PDE |
| algorithms | genetic algorithms | performance |
| analysis of variance | global analysis | periodic orbits |
| answer set programming | global convergence | periodic solutions |
| applications | global optimization | perturbation |
| approximation | GMRES | Petri nets |
| Arnoldi method | graph theory | planning |
| artificial intelligence | graphics | Poisson equation |
| astrophysics | grid computing | polynomial systems |
| asymptotic expansions | Gröbner bases | polynomials |
| asymptotic stability | group theory | porous media |
| automated reasoning | | preconditioning |
| automated theorem proving | | prediction |
| automatic differentiation | H | preprocessing |
| automorphism group | harmonic analysis | principal component analysis |

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Keywords for this software



References in zbMATH (referenced in 237 articles , 4 standard articles)

Showing results 1 to 4 of 4.

Sorted by: year / citations 20

1. Berthold, Timo; Heinz, Stefan; Vigerske, Stefan: Extending a CIP framework to solve MIQCPs (2012) 
2. Berthold, Timo; Gleixner, Ambros M.; Heinz, Stefan; Vigerske, Stefan: Analyzing the computational impact of MIQCP solver components (2012) 
3. Achterberg, Tobias: SCIP: solving constraint integer programs (2009) 
4. Berthold, Timo: Heuristics of the branch-cut-and-price-framework SCIP (2008) 

URL: scip.zib.de/

InternetArchive

Versions: -Info

Authors: Gerald Gamrath, Ambros Gleixner, Gregor Hendel, Stephen J. Maher, Matthias Miltenberger, Benjamin Müller, Marc Pfetsch, Felipe Serrano, Dieter Weninger, Jakob Witzig
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Licence: ZIB academic license

Current version: 3.2

Dependencies: LP-solver, e.g.
SoPlex, CPLEX, XPress, ...

Add information on this software.

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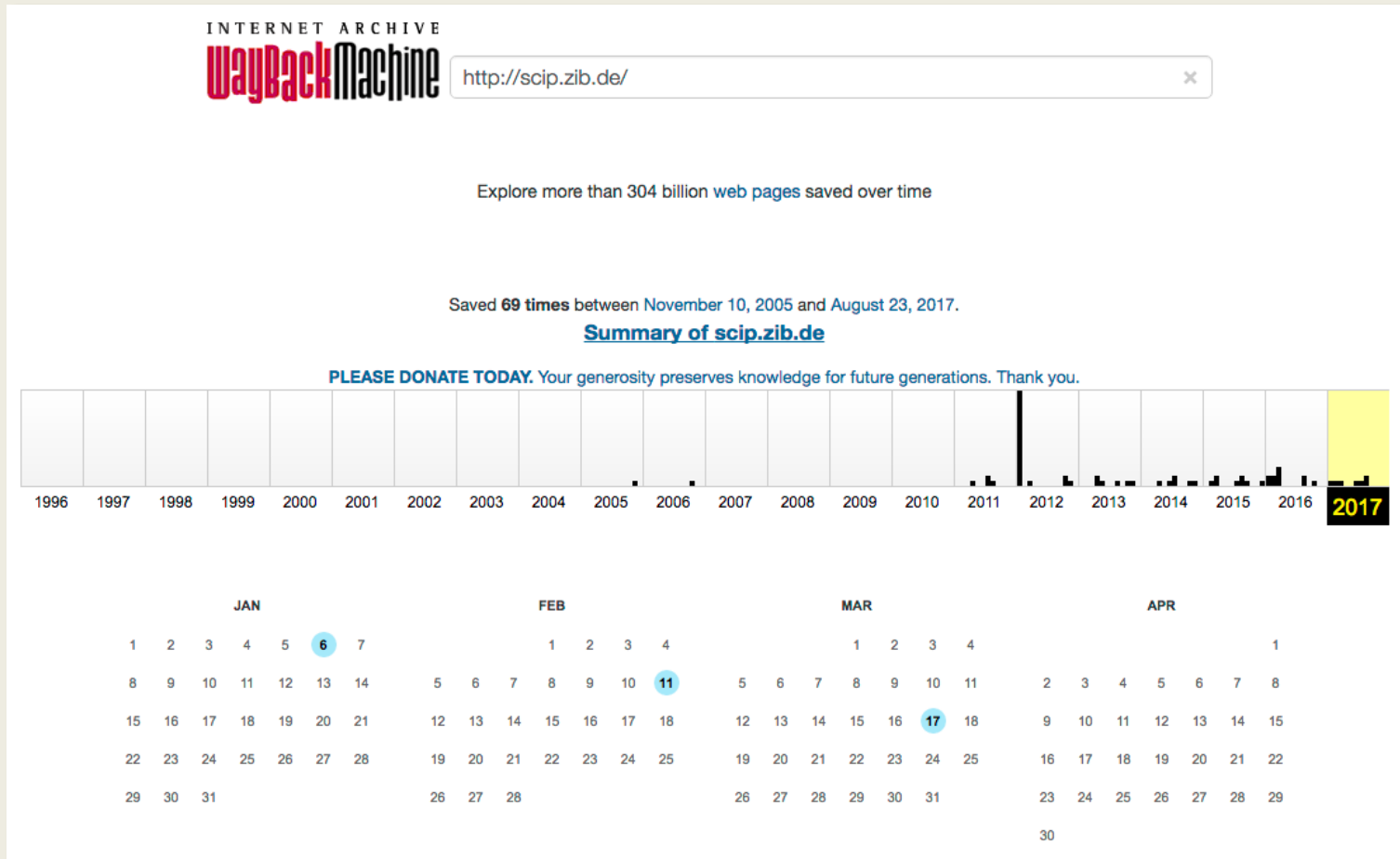
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 - 52 Convex and discrete...

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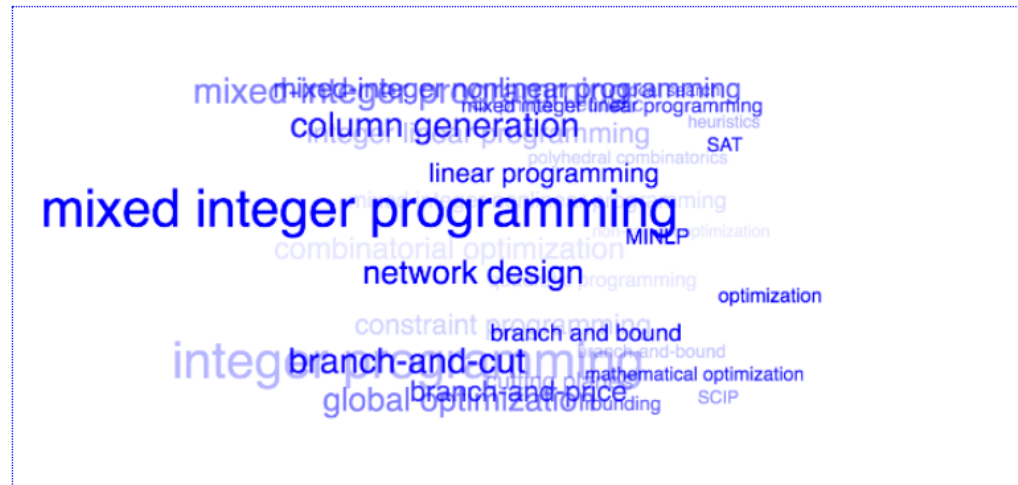
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52 Convex and discrete...

... leads to Tempas TimePortal (L3S)

Software **SCIP** in
Berthold, Timo; Heinz, Stefan; Vigerske, Stefan: Extending a CIP framework to solve MIQCPs (2012)

swMATH

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09/04/2011
year before publ.

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SCIP Optimization Suite

SCIP SoPlex ZIMPL UG GCG

Documentation

SCIP

Solving Constraint Integer Programs

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About

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Solver	Time (seconds)	Ratio (vs SCIP 4.0.0)
CBC 2.9.8	~1800	3.21x
MIPCL 1.3.1	~1200	1.36x
SCIP 4.0.0 - SoPlex 3.0.0	~600	1.00x
SCIP 4.0.0 - CPLEX 12.7.1	~500	0.85x
Xpress 8.1.0	~100	0.19x
CPLEX 12.7.1	~80	0.13x
Gurobi 7.0.0	~70	0.12x

data: Hans Mittelmann
graphics: ZIB

MIP solver benchmark (1 thread): Shifted geometric mean of results taken from the homepage of [Hans Mittelmann](#) (14/Apr/2017). Unsolved or failed instances are accounted for with the time limit of 2 hours.

What is SCIP?

A similar technique is used for solving both Integer Programs and Constraint Programs: the problem is successively divided into smaller subproblems (branching) that are solved recursively.

On the other hand, Integer Programming and Constraint Programming have different strengths: Integer Programming uses LP relaxations and cutting planes to provide strong dual bounds, while Constraint Programming can handle arbitrary (non-linear) constraints and uses propagation to tighten domains of

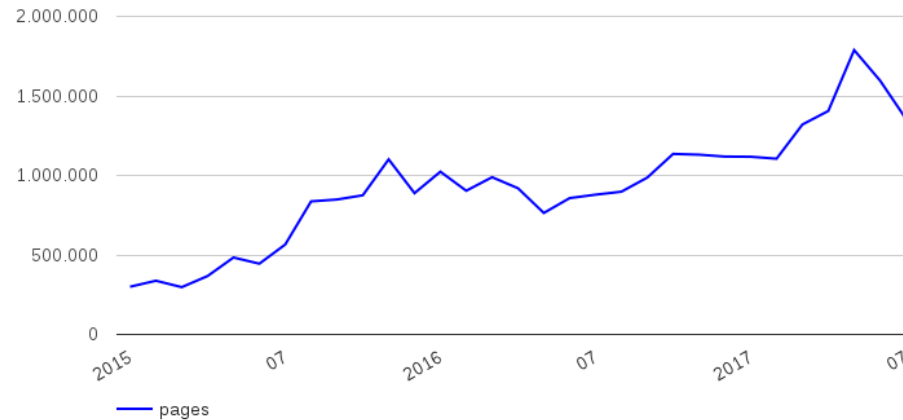
Some Statistics

- swMATH has been started in 2011, a joined project of Research Institute Oberwolfach (MFO) and FIZ Karlsruhe
- currently a project of the BMBF research campus MODAL with FIZ Karlsruhe/zbMATH and Zuse Institute Berlin (ZIB)
- ~19.000 Software Packages
- 240.000+ Software References in
- 140.000+ zbMATH (Scientific Articles)

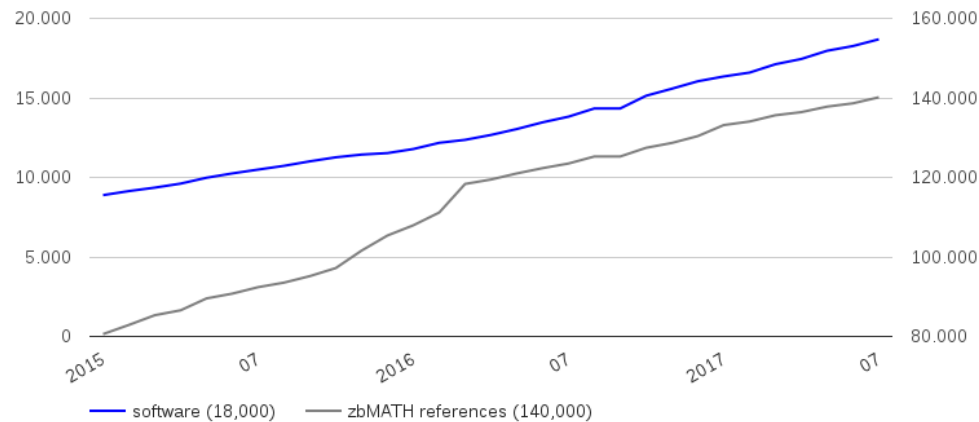
Usage of swMATH

swMATH-charts

Usage Statistics for swmath.org (Apache-Logfile, Webalizer-pages, with robots)
01.2015 - 07.2017



swMATH figures for software and zbMATH references
01.2015 - 07.2017



Some Results

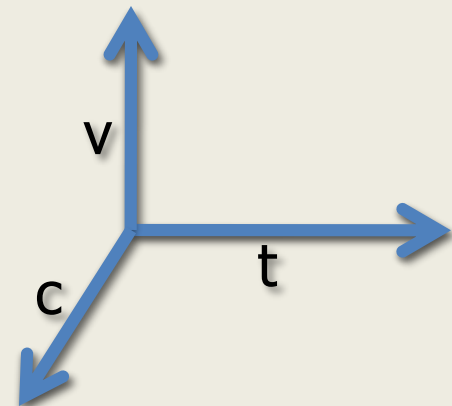
- the numbers of citations listed in swMATH is an indicator of acceptance, spread and quality of the software
- Software developer
 - receives more scientific recognition
 - gets more academic reputation
 - gets more credit points in his academic career
- swMATH pages can be use as landing pages for software containers

Outlook

- Software Citation Standard
- Software Citation Index
- Access to all relevant Software
 - ArXiv,
 - Google Scholar,
 - Github
 - ...
- Archiving
- Access by Time, Category and Version

software citation proposal:

```
@MISC{sw01091,  
author = {Gerald Gamrath, Ambros Gleixner, Gregor Hendel, Stephen J. Maher, ... }  
title = {SCIP},  
note = {[SW] SOI:swmath.01091 (\url{http://www.swmath.org/software/01091})}  
}
```



Agenda

- Introduction (W. Sperber):
 - Why we have proposed this meeting?
 - Software Citations and the Software Citation Principles
 - Open problems
- swMATH: The publication based approach and swMATH landing pages (W. Dalitz)
- Live Demo: Software archiving and structurization (H. Holzmann)
- Discussion

Live Demo

<http://www.swmath.org>

<http://tempas.L3S.de/Micrawler>

- **What is a micro archive?**
 - A micro archive is a snapshot of a fixed (evolving) set of URLs that are representative for some object or entity (at a given time). Hence, such an archive can be used to describe and / or derive information about its subject at the time of the crawl.
 - In case of software, it is a snapshot of resources on the Web that are related to that software, such as its website, documentation, source code or even binaries [1].
- Micrawler creates such micro archives based on a specification, which can be generated / provided by third-parties, like software repositories or catalogues (swMath)
 - Micrawler is modular and easy to extend / customize
 - Micro archives can be cited through unique identifiers
- **Micrawler on GitHub:** <https://github.com/helgeho/Micrawler>

[1] H. Holzmann, W. Sperber and M. Runnwerth. Archiving Software Surrogates on the Web for Future Reference. 20th International Conference on Theory and Practice of Digital Libraries (TPDL). Hannover, Germany. September 2016.

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Some topics for discussion

- New persistent identifiers for software products (SOIs) and software versions (SVOIs) instead DOIs?
- Is CodeMeta metadata scheme suitable for the variety of use cases? Who should create and maintain metadata?
- Which metadata can be extracted in swMATH?
- Can be the swMATH/Tempas approach also used in other fields?
- Use of Web archives for software
Do we need special archiving services for software?