
Distributed Symbolic Computations

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Overview

- The problem
- The past
- The present
- The future?

The problem

Symbolic computation?

- Automation of the steps of mathematical problem solving
- Modern field of CS and Math
which deals with symbolic objects, e.g. logical or algebraic formulae, rules or programs
- Main goal is exactness
- Examples of operations: diff, integral, factors, roots

Subfields of symbolic computing

- ***computer algebra (CA)***,
- automated theorem proving,
- computational combinatorics,
- computational geometry,
- automated programming,
- functional or logic programming.

Symbolic methods - applications

- computer aided design
- software development
- VLSI design
- geometric modelling
- reasoning
- robot programming
- human genome

etc

Problems behind CA systems

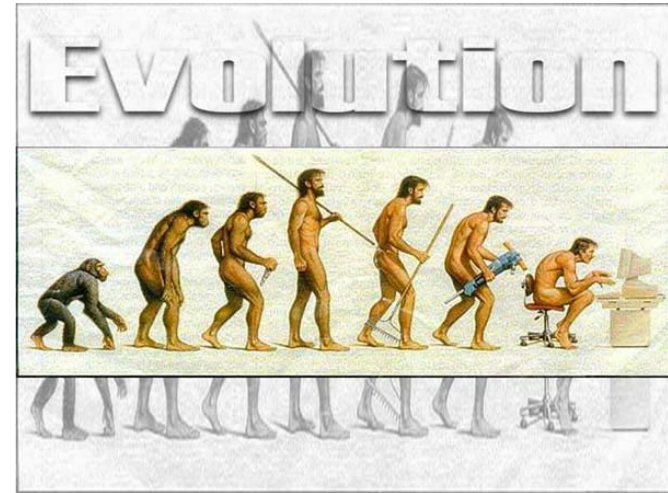
Lagging relative to numerical computing,
mainly due to the inadequacy of available
computational resources:

1. computer memory
2. processor power.

Solution: parallel & ***distributed CA***

- ❑ Solving larger problems
- ❑ Build new algorithms
- ❑ Build new systems

The past



Distributed computations emerge

From: Tilmann Bubeck, Martin Hiller, Wolfgang Küchlin, and Wolfgang Rosenstiel.
Distributed Symbolic Computation with DTS. In *Proc. of Parallel Algorithms for Irregularly Structured Problems*, LNCS, Lyon, France, Sep 1995. Springer. to appear.

Distributed Symbolic Computation with DTS

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University of Tübingen

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<http://www-ti.informatik.uni-tuebingen.de/dts>

Keywords: Parallel and Distributed Computing, Threads, Algebraic and Symbolic Computing, Irregular Load Balancing.

Abstract. We describe the design and implementation of the *Distributed Threads System* (DTS), a programming environment for the parallelization of irregular and highly data-dependent algorithms. DTS extends the support for *fork/join* parallel programming from shared memory threads to a distributed memory environment. It is currently implemented on top of PVM, adding an asynchronous RPC abstraction and turning the net into a pool of anonymous compute servers. Each node of DTS is multi-threaded using the C threads interface and is thus ready to run on a multiprocessor workstation. We give performance results for a parallel implementation of the RSA cryptosystem, parallel long integer multiplication, and parallel multi-variate polynomial resultant computation.

General reasons for parallelism

- ability to reduce the wall-clock time i.e. the user's waiting time for the solution problems that are *processor bound*
- Ability to solve problems that cannot fit into memory of a ``workstation'' problems that are *memory bound*

Memory bound is the driving force in parallelization of CA algorithms

Parallel symbolic algs. – 1990-2000

- Fast multiprecision integer arithmetic, eg. factorization, large integer multiplication
- Fast polynomial arithmetic, eg. GCD, factorization, differentiation
- Fast exact solution of linear equation systems
- Fast solution of polynomial equation systems via Groebner basis

M.Matooane, Parallel systems in symbolic and algebraic computation, PhD Thesis, 2001, University of Cambridge

Difficulties in building parallel or distributed symbolic computing systems

- Unpredictable data dependencies,
- Algorithmic dependence on irregular data which are difficult to be dynamically partitioned,
- In case of distributed memory, one processor can exceed its available memory, while there is still space available globally
- Complexity of some of algebraic computations limiting ability to estimate resource requirements
- developing completely new systems
 - is efficient,
 - but difficult
 - usually only a few parallel algorithms within such a system are fully implemented and tested

Adding parallelism

- develop CASs for shared memory architecture
- develop computer algebra hardware;
- add parallel primitives for communication and cooperation to existing CASs;
- build distributed memory systems based on standard communication middleware;
- build distributed systems for loosely coupled machines or across the Internet.

Example: Maple

<i>Author</i>	<i>Tool</i>	<i>Technology</i>
Char,'90	Sugarbush	C/Linda + Maple
Wang,'91	Parallel	Shared files + Maple
Siegl,'93	Maple	Strand + Maple
Bernardin,'97,	Maple for Paragon	Rewrite Maple
Diaz,Kartofen,'98	FoxBox	MPI + Maple
Schreiner,'98,	Distributed Maple	Java + Maple
Petcu, '01,	PVMaple	PVM + Maple

Schreiner et al., Distributed Maple-parallel computer algebra in networked environments J.Symbolic Comput.35(3),2003

Mathematical software

Thousands of codes of all kinds performing all kinds of symbolic computations:

- **General purpose systems:**

Axiom Aldor Derive Macsyma Magma Maple Mathematica MuPAD
Reduce etc

- **Special purpose systems:**

ACE Albert Algeb Amore Bergman Cannes / Parcan Carat Casa
Chevie C-Meataxe CoCoA Crep Desir Discreta Felix Fermat FoxBox
Gap GiNaC Kan/sm1 Kant LiDIA LiE BIGLIE Macaulay Mas Masyca
Moc NTL Pari Parsac Quotplic ReDuX RepTiles SAC-1 Aldes/SAC-2
Saclib SciNapse Senac Simath Singular SymbMath Symmetrica
Theorema Theorist etc

- **Packages:**

Arep Cali CLN Crack, LiePDE ApplySym ConLaw Dimsym EinS
FeynArts FormCalc FeynCalc Grape Molgen Orme Ratappr TTC etc

- Johannes Grabmeier, Erich Kaltofen, Volker Weispfenning , Computer Algebra Handbook, Springer, 2003
 - CAS: <http://www.symbolicnet.org>
-

User needs

- Users *may not be aware* of existing tools to solve their math problems
- Users may not be able to make *best choice*
- *Not realistic to install* all packages locally
 - Know specifics of all software
 - Maintain up-to-date licenses of all software
 - Even for rarely used ones
- Need to normalize, categorize, and discover operations performed by mathematical packages
- Need for a standard taxonomy
 - different packages perform the same operation under different names.
- Need semantic interface to abstract packages peculiarities

Challenge: find ways to re-use codes

- Standard representation of mathematical objects

solved recently

- Standard way to invoke, compose and discover mathematical packages

in progress

Mathematical Representation: OpenMath

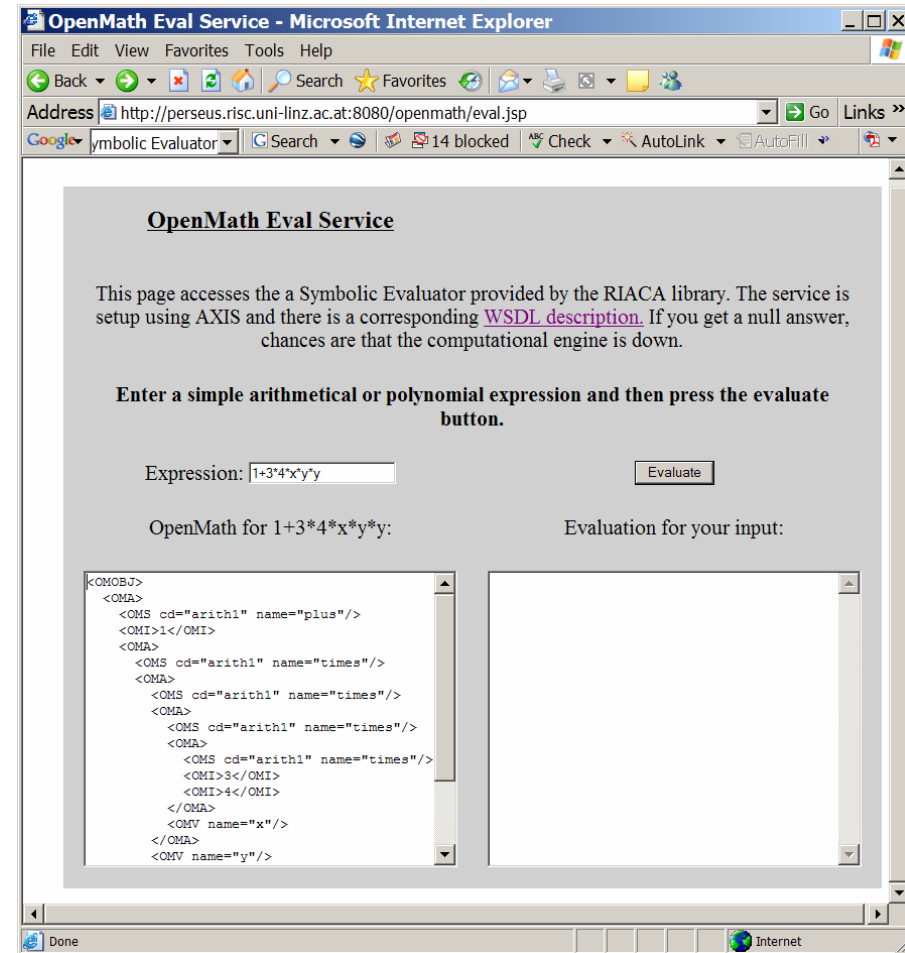
- Data formats for portable mathematical objects: OpenMath, MathML, OMDoc
- OpenMath: Standard developed by an European research consortium.
 - Abstract syntax model for mathematical objects
 - variable, symbol
 - quantifier (variable, object), application(object, object), annotation(object, object)
 - Concrete syntax representations
 - Content dictionaries (CDs)
 - Collections of constant (function/predicate) symbols
 - Standard set of CDs plus extensions

OpenMath

Maple: $\text{int}(\sin(x), x=1..10)$;

OpenMath

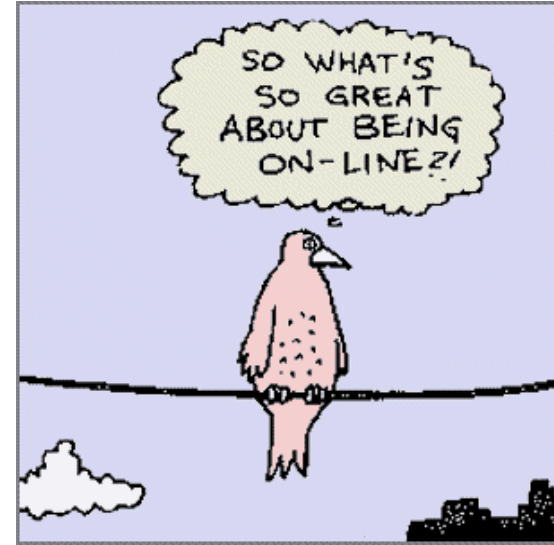
```
<OMOBJ>
  <OMA>
    <OMS cd="calulus1" name="defint"/>
    <OMA>
      <OMS cd="interval1" name="interval"/>
      <OMI> 1 </OMI>
      <OMI> 10 </OMI>
    </OMA>
  </OMA>
  <OMBIND>
    <OMBVAR>
      <OMV name="x"/>
    </OMBVAR>
    <OMA>
      <OMS cd="transc1" name="sin"/>
      <OMV name="x"/>
    </OMA>
  </OMBIND>
</OMA>
</OMOBJ>
```



Protocols and APIs for communications

- IAMC, MathWeb, JavaMath etc
- IAMC: Internet-Accessible Mathematical Computation
 - HTTP-like protocol for server-client communication:
 - Informal description of service provided.
 - Abstract protocol for service access
 - Requires insight to be used
- MathWeb
 - Software bus combining mathematical services
 - Broker providing access object for service by name
 - Abstraction from service locations and from object encodings

The present



E-Mathematics

- Resources:

- bibliographic data (lots, with meta-data)
- papers (lots, HTML)
- ***software (some, user interfaces)***

- Services:

- citation indexes (very used)
- ***computations (seldom used)***

Web-enabled systems

- MapleNet and webMathematica
- WIMS: WWW Interactive Mathematics Server

The screenshot shows a Microsoft Internet Explorer browser window titled "Factoris - Microsoft Internet Explorer". The address bar displays "http://wims.unice.fr/wims/wims.cgi". The page content includes a navigation menu with links for "WIMS Home", "References", "Help", "About", and "WIMS Help". The main heading is "Factoris". Below it, the text reads "Factorization of $n = 2^{2^2} - 8!$:" followed by the equation $25216 = 2^7 \times 197$. A "Remark" states that all factors are certified primes. There is an input field for "Another formula to factor" containing the expression $2^{(2^{(2^2)}-8)}$. Below this, instructions explain how to type formulas. A "Menu of options" button is visible. At the bottom, there are links for "WIMS Home", "Help", and "About", along with author information: "Author of the page: XIAO Gang" and "Version 1.60, © 1997-1999 (GNU GPL) 2004".

Internet projects

<http://distributedcomputing.info/ap-math.html>

- finding large prime numbers,
- factoring large numbers,
- computing digits of Pi,
- finding collisions on known encryption algorithms etc.



Towards automatization

Consumers of resources and clients of services:

- Humans
- Databases
- ***Software***
- ***Other resources and services***

Initiatives for Mathematical Web services

- MONET (2002-2004) demonstrated the applicability of the semantic Web to the world of mathematical software (discover services dynamically)
- MathWeb-SB (2003) – access via broker by name
- MathBroker (2005-2007) – Web registry to publish/discover

MONET

- Ability to *discover services dynamically* based on published descriptions which express both their mathematical and non-mathematical attributes
- A *symbolic solver wrapper* was designed

MONET Symbolic Services
University of Western Ontario
Ontario Research Centre for Computer Algebra

Client for Indefinite Integration Service

Result format:

integrand URL ([OpenMath expression repository](#))

or expression ([OpenMath expression editor JOME](#))

bound variable URL ([OpenMath expression repository](#))

or expression ([OpenMath expression editor JOME](#))

Service call flow pattern: direct via broker

Result format:

Result:

```
-\ln \left( \cos \left( x \right) \right)
```

Initiatives for Mathematical Grid services

- Why Grid?
 - Whereas the Web is a service for sharing information over the Internet, the Grid is a **service for sharing computer power and data storage** capacity over the Internet
 - High potential as discovery accelerator
 - Way to categorize, explore, discover, invoke and compose thousand of software packages
- GENSS – follows MONET, research on advertisement and discovery, ontology
- GEMLCA – deploy a legacy code

D.Petcu, D.Tepeneu, M.Paprzycki, T.Ida, Symbolic Computations on Grids, Chapter 6 in the book "Engineering the Grid: status and perspective", eds. Beniamino di Martino, et al ASP, 2006, pp. 91-107

GENSS

- Grid Enabled Numerical and Symbolic Services, initiated in 2004
<http://genss.cs.bath.ac.uk/index.htm>
- research was focused in two areas:
 1. matchmaking techniques for advertisement and discovery of mathematical services,
 2. design and implementation of an ontology for symbolic problems

Search services

Home
List services
Search services

Algorithm
GAMS class:

Number of Pre- and Post-conditions
Number of Pre-Conditions: Number of Post-Conditions:

Search for

structural match syntax and ontological match algebraic equivalence match substitution of values match

Pre-condition:

Pre-condition:

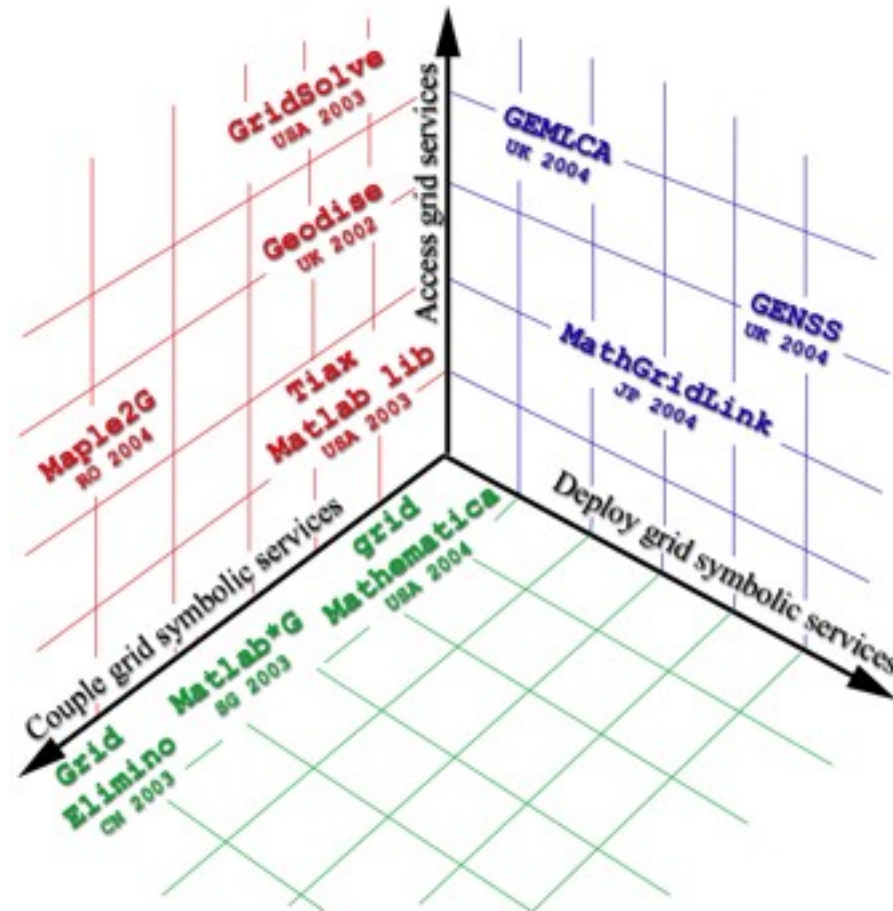
Post-condition:

Post-condition:

Returned Matches

Service Name:	Service URL:	Match Type:	Match Score Pre-Conds:	Match Score Post-Conds:	Overall Match Score:	Match Indicator:
Factorisor	http://alis.cs.bath.ac.uk:9050/axis/maple-service/www/invoke/TSInvokeService.jsp?nameService=factorisor	structural	0.66667	0.0	0.333335	Medium
Quad_Sieve	http://alis.cs.bath.ac.uk:9050/axis/maple-service/www/list/TListService.jsp?nameService=Quad_Sieve	structural	0.00357	0.0	0.001785	Low

Symbolic computations on Grids



SCIENCE project (2006-2011)



SCIENCE – Symbolic Computation Infrastructure in Europe

<http://www.symbolic-computation.org>

5-year project supported by the EU Framework VI programme grant RII3-CT-2005-026133.

The screenshot shows the homepage of the SCIENCE project website. The browser address bar displays <http://www.symbolic-computation.org/>. The page layout includes a navigation menu with links for home, partners, documentation, projects, intranet, links, and contact. A 'log in' button is also present. The main content area is titled 'Welcome to SCIENCE' and contains the following text:

The SCIENCE project (Symbolic Computation Infrastructure for Europe) brings together the developers of four powerful symbolic computation software packages and a major symbolic computation research institute supported by research groups expert in essential underpinning technologies, to unite the European community of researchers in, and users of, symbolic computation. The project will promote the development of new software made more efficient by sharing components and expertise, more interoperable in the modern Web services environment and ready for the coming environment of Grid computing.

The project is an Integrated Infrastructure Initiative, funded by the European Commission under the Research Infrastructures Action of Framework 6. It began on 1 April 2006 and runs for 5 years.

The partners in the project are:

- The Centre for Interdisciplinary Research in Computational Algebra (St Andrews, Scotland), coordinating <http://www-circa.mcs.st-and.ac.uk>
- RISC-Linz, Austria <http://www.risc.uni-linz.ac.at>
- The MuPAD group at the University of Paderborn, Germany
- The KANT group at the Technical University of Berlin, Germany
- The Computer Algebra group at the Technical University of Eindhoven, Netherlands
- Institute e-Austria Timisoara, Romania, <http://www.ieat.ro>
- Maplesoft, Inc, Waterloo, Canada, <http://www.maplesoft.com>
- The Dependable Systems Research Group at Herriot-Watt University, Scotland

A calendar for June 2007 is displayed on the right side of the page, with the 21st highlighted.



R&D in SCIEnce

- **Software composability:**
 - a programme of standards developments and implementations for symbolic computation software to use Web services and OpenMath technologies, allowing them to be efficiently composed to solve complex problems
- **Symbolic computing on Grids:**
 - developing common standards and middleware to allow the production of Grid-enabled symbolic computation systems constructing research prototypes supporting appropriate security, scheduling, and resource broking for complex symbolic computing applications on computational Grids

SCIENCE consortium



University of St Andrews, St Andrews, UK



Research Institute for Symbolic Computation, Linz, Austria



Centre National de la Recherche Scientifique, France



Universität Paderborn, Germany



Technische Universiteit Eindhoven, Netherlands



Technische Universität Berlin, Germany



Institute e-Austria Timisoara, Romania



Maplesoft, Waterloo, Canada



Heriot Watt University, Edinburgh, UK



GAP



KANT/KASH



Maple



MuPAD

SCIENCE: Software composability

Designed the Symbolic Computation Software Composability Protocol (**SCSCP**) :

by which a computer algebra system (CAS) may offer services for the following clients:

- ❑ a Web server which passes on the same services as Web services using SOAP/HTTP protocols to another clients
- ❑ Grid services
- ❑ Another instance of the same CAS (in a parallel computing context)
- ❑ Another CAS running on the same computer or remotely

A. Konovalov, S. Linton. Symbolic Computation Software Composability Protocol Specification. CIRCA preprint 2007/5, University of St Andrews. <http://www-circa.mcs.st-and.ac.uk/preprints.html>

SCIEnce: using OpenMath

- All messages in the protocol are represented as OpenMath objects, using the new Content Dictionary **cascall1** developed for this purpose.
- **SCSCP** specifies: Semantical and technical descriptions of OpenMath-encoded messages to and from CAS:
 - remote procedure call
 - returning result of successfully completed procedure
 - returning a signal about procedure terminationand also allowed sequences of these messages.

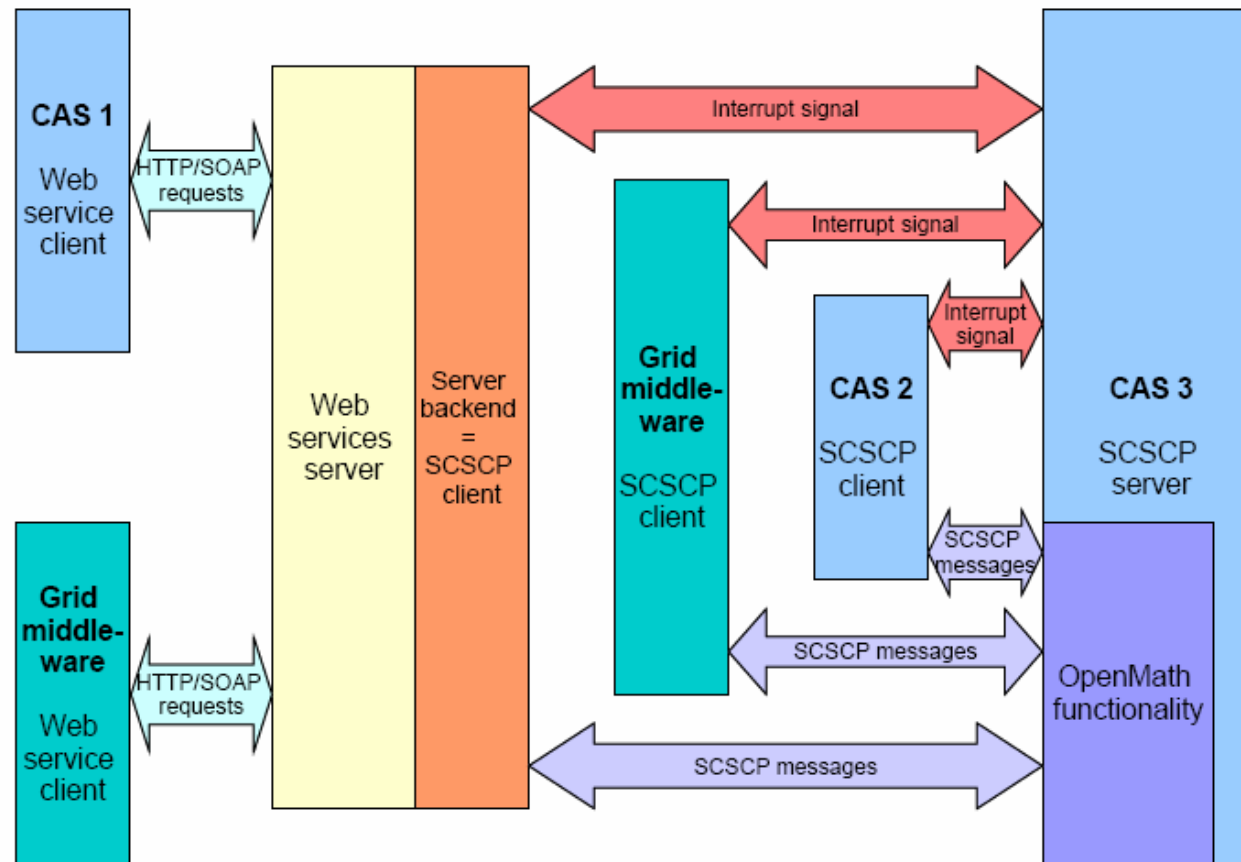
D. Roozmond. OpenMath Content Dictionary cascall1. <http://www.win.tue.nl/SCIEnce/cds/cascall1.html>

SCIENCE: cascall1

In the next example we retrieve the group [24,12] from GAP Small Groups Library, creating it at the GAP side and requesting a cookie for it (omitted options will be set to default values):

```
<MOBJ>
  <MATTR>
    <MATP>
      <OMS cd="cascall1" name="call_ID" />
      <OMSTR>alexk_9053</OMSTR>
      <OMS cd="cascall1" name="option_return_cookie" />
      <OMSTR/>
    </MATP>
    <OMA>
      <OMS cd="cascall1" name="procedure_call" />
      <OMSTR>GroupByCatalogueNumber</OMSTR>
      <OMI> 24</OMI> <!-- Argument 1 -->
      <OMI> 12</OMI> <!-- Argument 2 -->
    </OMA>
  </MATTR>
</MOBJ>
```

SCIEnce: Current vision of SCSCP



SCIEnce: Work in progress

- Adding basic SCSCP implementations to all systems
- Identifying and developing new OpenMath content dictionaries and other standards extensions needed
- Adding support of selected OpenMath CDs in all systems
- Implementing higher level interfaces in all systems

Overall objectives for symbolics on Grids

- Produce a portable framework (**SymGrid-Services**) that will allow:
 - symbolic computations to access Grid services
 - symbolic components to be exploited as part of larger Grid service applications on a computational Grid
- Develop resource brokers that will support the irregular workload and computation structures that are frequently found in symbolic computations (**SymGrid-Par**)
- Implement a series of applications that will demonstrate the capabilities and limitations of Grid computing for symbolic computations

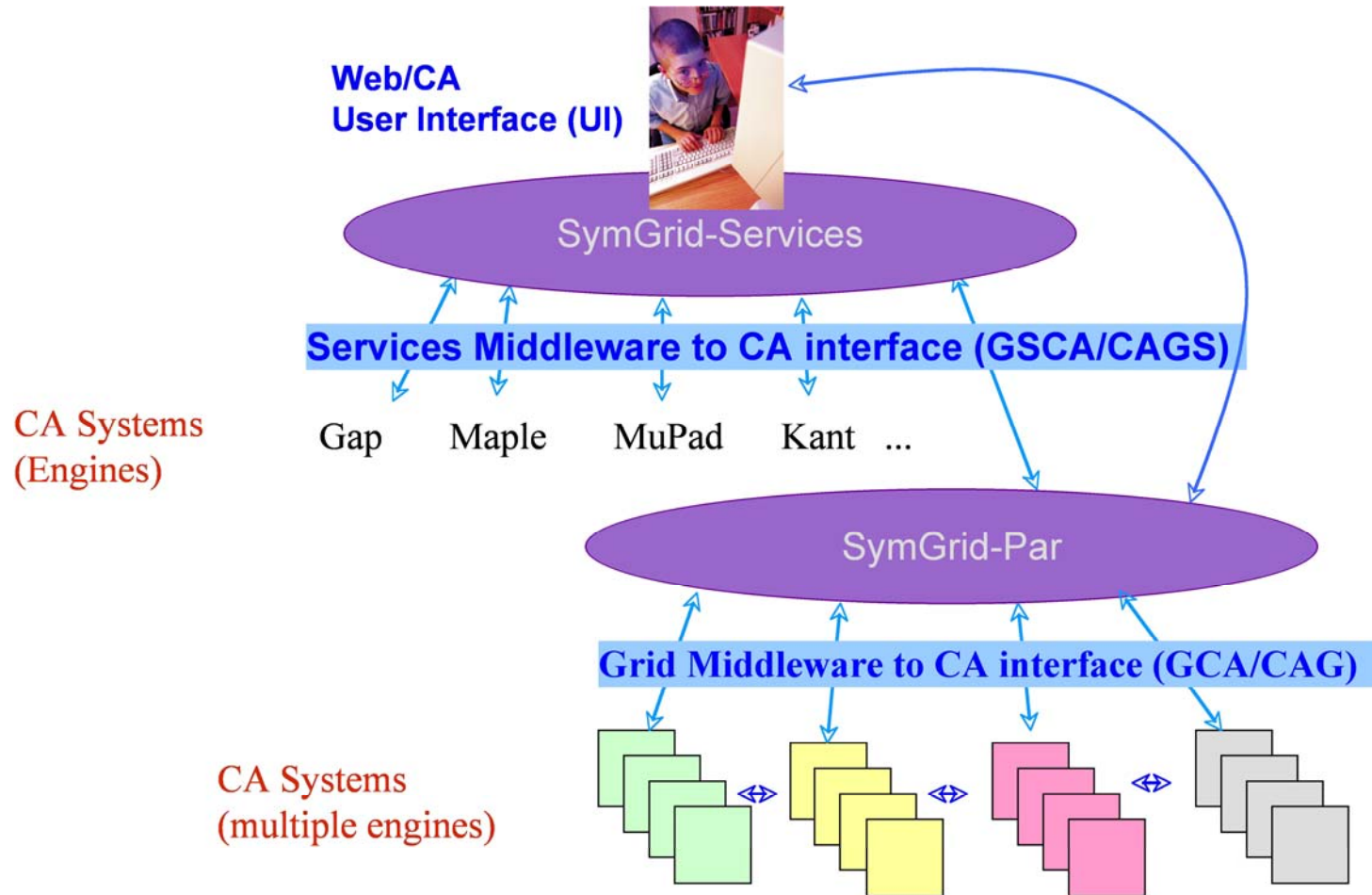
SCIENCE's SymGrid

- A new middleware is developed – **SymGrid** – to allow the construction of large-scale Grid-enabled symbolic applications.
- SymGrid components:
 - **SymGrid-Services** to provide access to Grid services from symbolic applications
 - **SymGrid-Par** to support the construction of high-performance applications on computational Grids.
- **SymGrid-Par** is built around **GRID-GUM**, a system designed to support parallel computations on Grids and adapted to interface with symbolic computation engines

Al Zain, P. Trinder, H.-W. Loidl and G. Michaelson. Managing Heterogeneity in a Grid Parallel Haskell. J. Scalable Comp.: Practice and Experience, 6(4), 2006.

A. Carstea, M. Frincu, G. Macariu, D. Petcu, K. Hammond. Generic Access to Web and Grid-based Symbolic Computing Services – the SymGrid-Services Framework. Proc. ISPDC 07

SymGrid architecture



Training schools at RISC, 2007-2010

- The 1st school was held on February 5-18, 2007
- The 2nd school is taking place on June 25 – July 6, 2007
- One school each year in 2008–2010



Transnational Access Programme

  **Research Institute for Symbolic Computation**
Johannes Kepler University Linz
Austria  

Supported by the European Commission Framework 6 Programme for Integrated Infrastructures Initiatives under the project SCIENCE

Transnational Access to RISC
RISC-Linz, a research institute at the Johannes Kepler University in Linz, Austria, within the project SCIENCE (2006–2011) offers opportunities to obtain:

- Free access to the infrastructure, facilities, and expertise of a world-leading center in symbolic computation.
- Scientific, technical, administrative, and logistic support, including travel and living expenses.

Targeted Audience
Researchers and students interested in using symbolic computation in their work.

Selection Panel
Bruno Buchberger, Arjeh M. Cohen, Marc Giusti, Steve Linton, Peter Paule, Franz Winkler (Chair)

Scientific Adviser
Temur Kutsia

Detailed Information and Application Procedure
<http://www.risc.uni-linz.ac.at/projects/science/access/>



PASCO

Symbolic-Numeric Computation 2007

www.orcca.on.ca/conferences/snc2007

July 25-27, 2007

Invited Speakers

André Galligo, U Nice
Erich Kaltofen, NCSU
Nick Trefethen, U Oxford
Charles Wampler, GM Research
Lihong Zhi, MMRC CAS

Topics

- Hybrid symbolic-numeric algorithms
- Approximate polynomial GCD and factorization
- Symbolic-numeric methods for polynomial systems
- Structured matrices in symbolic-numeric computation
- Differential equations for symbolic-numeric computation
- Symbolic-numeric algorithms for algebraic geometry, geometric computation and optimization
- Implementation of symbolic-numeric algorithms
- Model construction with approximate algebraic algorithms
- Applications of symbolic-numeric computation
- Numerical algebraic geometry

Important Dates

Submission deadline: April 9, 2007
Notification: May 28, 2007
Camera ready version due: June 15, 2007

Program Committee

Dario Bini, Italy
Robert Corless, Canada
James Demmel, USA
Ioannis Emiris, Greece
Marc Moreno Maza, Canada
Bernard Mourrain, France
Victor Pan, USA
Greg Reid, Canada
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Administration: Meg Borthwick

General Chairs: Marc Moreno Maza (PASCO)
Administration: Meg Borthwick

Local Arrangements: Oleg Golubitsky
Publicity: Eric Schoot

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Publicity: Eric Schoot

Local Arrangements: Oleg Golubitsky
Publicity: Eric Schoot

Parallel Symbolic Computation 2007

www.orcca.on.ca/conferences/pasco2007

July 27-28, 2007

Invited Speakers

Mike Bauer, UWO
Matteo Frigo, Cilk Arts
Thierry Gautier, INRIA
Katherine Yelick, UC Berkeley

Topics

- Parallel computer algebra
- High performance for exact and approximate procedures
- Analysis of parallel algorithms for algebraic computations
- Parallel computing for number theory, combinatorial and discrete methods
- Distributed data-structures for algebraic computation
- Implementations of solvers on multi-cores, SMPs, clusters, supercomputers and grids
- Interactive parallel symbolic computation
- Volunteer computing for symbolic problems
- Applications of parallel symbolic computation

Important Dates

Submission deadline: April 16, 2007
Notification: May 28, 2007
Camera ready version due: June 15, 2007

Program Committee

Gene Cooperman, USA
Jean-Guillaume Dumas, France
Jean-Charles Faugère, France
Mark Giesbrecht, Canada
Erich Kaltofen, USA
Anton Leykin, USA
Marc Moreno Maza (Chair), Canada
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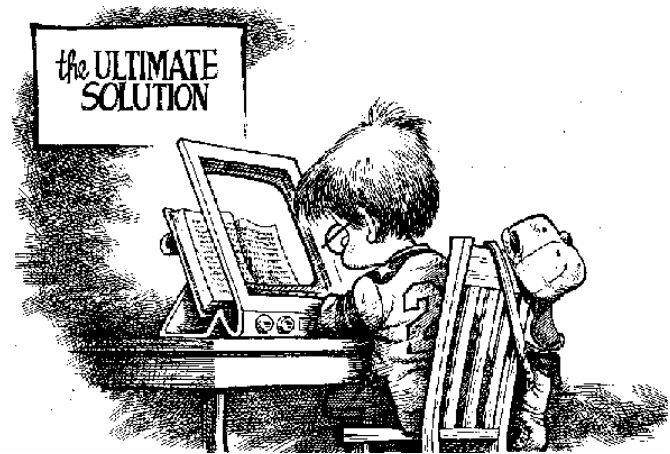
Local Arrangements: Oleg Golubitsky
Publicity: Eric Schoot

Local Arrangements: Oleg Golubitsky
Publicity: Eric Schoot



University of Western Ontario, London Canada

The future



Specialized services and search engines

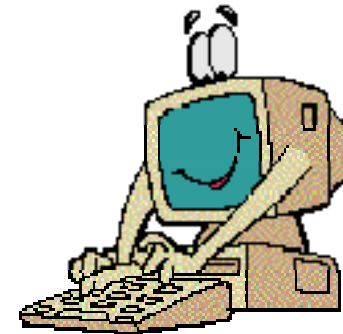
The image displays two screenshots from a Mozilla Firefox browser window. The left screenshot shows the search engine's main interface with search criteria: 'Prime Number domain:com', 'Country: United States', and 'Domain: com'. Below the search bar, there are sections for 'Keyword', 'Country', 'Domain', and 'Tag'. The right screenshot shows the 'Service Details' for 'JHConwayPrimeNumbers', including a description, WSDL URL, and a list of interfaces: 'JHConwayPrimeNumbersHttpPost', 'JHConwayPrimeNumbersSoap', and 'JHConwayPrimeNumbersHttpGet'. The 'JHConwayPrimeNumbersSoap' interface is expanded to show its operations: 'GetPrimesAsString', 'GetPrimesAsNumbers', and 'DurationEstimation'.

Web Services Search Engine - Mozilla Firefox
http://search.aleph-webservices.com/?q=Prime
Welcome petcu@info.uvt.ro [Logout](#) | [My Account](#) (If you're...)
Prime Number domain:com [Advanced Web Ser...](#)
Keyword Prime Number
E.g. "fax", "fax OR sms"
Country United States
This restricts your search to the country the Web Service is hosted.
Domain com
e.g. "com", "xignite.com". Note this restricts the domain of the end service is actual hosted) and not the domain of where the WSDL has
Tag
e.g. "fax", "sms", only services with this specific tag will be found.
about 2 searched results for "Prime Number domain:com country:US" (in 1 10)
JHConwayPrimeNumbers www.www-it.com
The service provides methods to look for prime numbers. They are based on the John Horton Conway's method, professor of mathematics at Princeton University. The method is described in "The book of numbers" written by Richard K. Guy and John Horton Conway ISBN 3-7643-5244-2. The method has been enhanced and coded by Mr. Ludwig-Rudolph Welther. Caution: the functions could last a long time. Therefore It is recommended to call them asynchronously.
Service operations: [GetPrimesAsNumbers](#), [GetPrimesAsString](#), [D](#)
[Service Details](#) [Add Tag](#) [Add/edit Service Wiki](#)
XOA xoa.xpedite.com
Service operations: [JobList](#), [ListRetrieve](#), [JobSubmit](#), [ListLi](#)
[Service Details](#) [Add Tag](#) [Add/edit Service Wiki](#)
(10089 distinct endpoints indexed)
Done

Aleph Web Services - Service Details - Mozilla Firefox
http://search.aleph-webservices.com/details?u...
Service Details
Name JHConwayPrimeNumbers
Beschreibung The service provides methods to look for prime numbers. They are based on the John Horton Conway's method, professor of mathematics at Princeton University. The method is described in "The book of numbers" written by Richard K. Guy and John Horton Conway ISBN 3-7643-5244-2. The method has been enhanced and coded by Mr. Ludwig-Rudolph Welther. Caution: the functions could last a long time. Therefore It is recommended to call them asynchronously.
WSDL <http://www.www-it.com/Mathematics/JHConwayPrimeNumbers.asmx?wsdl>
Cache [as XML](#), [as HTML](#)
Provider www.www-it.com
Hosted in United States (USA)
Schnittstellen
The JHConwayPrimeNumbers service has the following interfaces:
JHConwayPrimeNumbersHttpPost (HTTP_POST)
13 operation(s) defined for this Interface
JHConwayPrimeNumbersSoap (SOAP11_HTTP)
Operations:
• **GetPrimesAsString**(GetPrimesAsString) :GetPrimesAsStringResponse
Looks for the prime numbers beginning with the given number. 1 to 5 prime numbers can be found out. Arguments: the number (long), how many prime numbers to find out, max. duration in minutes (long) to look for, max. value (long) to look for. Max. duration = 0 indicates no time limit and max. value =...
• **GetPrimesAsNumbers**(GetPrimesAsNumbers) :GetPrimesAsNumbersResponse
Looks for the prime numbers beginning with the given number. 1 to 5 prime numbers can be found out. Arguments: the number (long), how many prime numbers to find out, max. duration in minutes (long) to look for, max. value (long) to look for. Max. duration = 0 indicates no time limit and max. value =...
• **DurationEstimation**(DurationEstimation) :DurationEstimationResponse
Evaluates the duration to look for the prime number 31.
JHConwayPrimeNumbersHttpGet (HTTP_GET)
13 operation(s) defined for this Interface
Done

Dynamic service composition

The current trend is to create environments with self-combining mathematical services



“The market of Five computers”

n's Computer Zen - The Skynet Compute Cloud: I think there is a world market for maybe Five Computers - Mozilla Firefox

History Bookmarks Tools Help

http://www.hanselman.com/blog/TheSkynetComputeCloudIThinkThereIsAWorldMarketForMaybeFiveComputers.aspx

Free Hotmail Windows Marketplace Windows Media Windows

Scott Hanselman's Computer Ze... Scott Hanselman: Value of Writing Win...

"I think there is a world market for maybe five computers"

but it might have been **Thomas Watson** in 1943, president of IBM, but it might be a myth.

The thinking was that a number of large mainframe computers would be built and used by the world. That of course, didn't happen, as my watch has more memory than **ENIAC** did, and there's computers everywhere, but as the web continues to mature, I believe that things will **conflate** in the next 10-15 years and as more and more companies begin to

- » outsource storage to services like **S3**
- » move servers into **Virtual Machines**
- » move all email and apps to **Google Apps**


All this is building a collective trust with large entities like Amazon, and as prices fall with uptimes rising, more companies will say, *"who am I to build a datacenter? I'll just host in one of The Five."*

Here's a list of services (by no means exhaustive) from Wikipedia's **Utility Computing** article, as of today:

- » **Amazon S3** - Bulk storage and bandwidth for static content
- » **Amazon EC2** - Pay by the hour CPU
- » **NearlyFreeSpeech** - Pay as you go web hosting for web pages, dynamic content, domains, DNS, etc
- » Sun Microsystems **Sun Grid** - Pay by the CPU hour
- » **Strikeiron** Web Services Marketplace - Pay per Web API call.
- » **USi** an **AT&T** company - USiPinnacle - Pay-as-you-go enterprise applications
- » **Zimki** - J avascript based utility computing system. Pay by bandwidth, storage, and javascript operations.
- » **ElasticLive** Utility web hosting service based on Amazon's Elastic Compute Cloud
- » **InsynQ** utility computing services
- » **CPAASP** online accounting solutions for on-demand enterprises
- » **Distributed Potential** Pay-Per-Use Grid Computing Capacity
- » **Dell Inc.** have a specific Cloud Computing Solution through their Datacenter Solutions Division

I believe this list will likely turn into **The Five Computers**:

1. Google (Apps)
2. Amazon (EC2)
3. Microsoft (Live)
4. Sun (Grid)
5. A network of installed bots on every small computer, possibly built into the OS, to use idle CPU cycles for the collective.



Expect to solve them

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Discrete Mathematics
Foundations of Mathematics
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Created, developed, and
nurtured by Eric Weisstein
at Wolfram Research



Unsolved Problems




COMMENT
On this Page

There are many unsolved [problems](#) in mathematics. Some prominent outstanding unsolved problems (as well as some which are not necessarily so well known) include

1. The [Goldbach conjecture](#).
2. The [Riemann hypothesis](#).
3. The conjecture that there exists a [Hadamard matrix](#) for every positive multiple of 4.
4. The [twin prime conjecture](#) (i.e., the conjecture that there are an infinite number of [twin primes](#)).
5. Determination of whether [NP-problems](#) are actually [P-problems](#).
6. The [Collatz problem](#).
7. Proof that the [196-algorithm](#) does not terminate when applied to the number 196.
8. Proof that 10 is a [solitary number](#).
9. Finding a formula for the probability that two elements chosen at random generate the [symmetric group](#) S_n .
10. Solving the [happy end problem](#) for arbitrary n .
11. Finding an [Euler brick](#) whose space diagonal is also an integer.
12. Proving which numbers can be represented as a sum of three or four (positive or negative) [cubic numbers](#).
13. [Lehmer's Mahler measure problem](#) and [Lehmer's totient problem](#) on the existence of [composite numbers](#) n such that $\phi(n) \mid (n-1)$, where $\phi(n)$ is the [totient function](#).
14. Determining if the [Euler-Mascheroni constant](#) is [irrational](#).
15. Deriving an analytic form for the square site [percolation threshold](#).
16. Determining if any odd [perfect numbers](#) exist.

The Clay Mathematics Institute (<http://www.claymath.org/millennium/>) of Cambridge, Massachusetts (CMI) has named seven "Millennium Prize Problems," selected by focusing on important classic questions in mathematics that have resisted solution over the years. A \$7 million prize fund has been established for the solution to these problems, with \$1 million allocated to each. The problems consist of the [Riemann hypothesis](#), [Poincaré conjecture](#), [Hodge conjecture](#), [Swinerton-Dyer Conjecture](#), solution of the [Navier-Stokes equations](#) , formulation of [Yang-Mills theory](#) , and determination of whether [NP-problems](#) are actually [P-problems](#).

In 1900, [David Hilbert](#)  proposed a list of 23 outstanding problems in mathematics ([Hilbert's problems](#), a number of which have now been solved, but some of which remain open. In 1912, Landau proposed four simply stated problems, now known as [Landau's problems](#), which continue to defy attack even today. One hundred years after Hilbert, Smale (2000) proposed a list of 18 outstanding problems.

K. S. Brown, D. Eppstein, S. Finch, and C. Kimberling maintain webpages of unsolved problems in mathematics. Classic texts on unsolved problems in various areas of mathematics are Croft *et al.* (1991), in [geometry](#), and Guy (1994), in [number theory](#).

SEE ALSO: [Beal's Conjecture](#), [Catalan's Conjecture](#), [Fermat's Last Theorem](#), [Hilbert's Problems](#), [Kepler Conjecture](#), [Landau's Problems](#), [Mathematics Contests](#), [Mathematics Prizes](#), [Poincaré Conjecture](#), [Problem](#), [Solved Problems](#), [Szemerédi's Theorem](#), [Twin Primes](#). [[Pages Linking Here](#)]

Instead conclusions

"It is reasonable to expect that in the year 2010, the predominant way of doing math will no longer be by pen and paper, but in an integrated *web-based math-development sys.* that supports the mathematician in all aspects of mathematics. "

Michael Kohlhase,
MathWeb project (<http://www.mathweb.org/>)

QUESTIONS ?
