A system for Computing in Commutative Algebra

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CoCoA is a *special-purpose* system for doing

*Computations in Commutative Algebra*

For instance: univariate polynomial factorization, exact linear algebra, Hilbert functions, ideals of points, toric ideals, etc.

It is *freely available* software for research and educational purposes: the latest version is CoCoA 4.1 which can be obtained by anonymous ftp or from our web site as well as from the mirror sites in Germany, Canada and USA.

It runs on Linux, LinuxPPC, Unix, Macintosh and Microsoft Windows.
CoCoA is one of the products of our research team in Computer Algebra whose members are:

L. Robbiano, J. Abbott,  
V. Augustin, A. Bigatti, M. Caboara,  
M. Kreuzer, D. Perkinson, A. Polverini  
and occasionally other researchers and students.

Many algorithms implemented in CoCoA are original research of the members of the CoCoA Team and are among the most efficient available in Computer Algebra Systems.

A list of papers describing the algorithms can be found at the CoCoA web site.
CoCoA was one of the few systems to have been invited to participate in the Special Session on Mathematical Software at ICM’98 and ECM’00.

Currently CoCoA is used by researchers in several countries. Its main use is in Commutative Algebra and Algebraic Geometry, but it has also been used in Statistics and Analysis.

CoCoA has also been used to effect some large calculations: for example, that described in the paper Abbott: “Sparse Squares” (Math. Comp.) A list of many papers citing CoCoA can be found at the CoCoA web site.
CoCoA is also used for teaching advanced courses in several universities around the world.

It is mentioned in some of the most widely used text books in Computational Algebra, and plays a major role in the book

M. Kreuzer, L. Robbiano

*Computational Commutative Algebra 1*

Springer (2000)

The tutorial pages from this book are used in courses at Genoa and are available at our web site.
A brief history of CoCoA

◇ 1989: First release of CoCoA at the COCOA II Conference in Genoa. Developed by A. Giovini and G. Niesi in the Pascal language. Initially the system was running only on Macintosches.

◇ 1995: A new CoCoA is released at the COCOA IV Meeting in Genoa. Written in C by A. Capani and G. Niesi, and available for all common platforms and operating systems. It now included a dedicated high-level programming language.

◇ 2001: ...
Why make a completely new version?

- new **object-oriented** programming languages have become widely available (e.g. C++, and Java)
- a **change in principal author** of CoCoA 3
- the **source code** for CoCoA 3/4 is **chaotic**, a result of evolution and growth greater than was originally foreseen, so further development is difficult
- CoCoA 3/4 has some **innate limitations**
- desire to make CoCoA an **open source** program
Currently CoCoA 4 is available only as an interactive system. We plan to offer CoCoA 5 in several guises

- as a C++ library which is fast, clean(ish) and well documented
- as a server which communicates using OpenMath
- as a standalone interactive system — possibly achieved by building a UI/GUI which sends requests to the server. The user language will preserve a high degree of backward compatibility with the current CoCoA language.
Design Aims for CoCoA 5

CoCoA 5 should be **better** than CoCoA 4, and never worse (e.g. faster, easier to use, more capabilities)

- wider choice of coefficient rings: algebraic extensions, function fields (i.e. parameters), floats(?)
- exploit multi-graded structure in Buchberger’s algorithm along the lines of Robbiano and Kreuzer, volume 2
- easier to create and use different rings contemporaneously
- slicker help system
- introduce types into the CoCoA programming language
An early prototype implementation of Buchberger’s algorithm exists. The prototype comprises the following components:

- customized memory management (manual, not automatic)
- only integer/rational coefficients so far (GMP in C++)
- various versions of power products — allows experimentation and gathering of statistics
- just enough polynomial operations to permit us to run Buchberger’s algorithm
- geobuckets
In the **immediate future** work on CoCoA 5 will be largely directed at: more types of coefficient ring, fine-tuning Buchberger’s algorithm, and the new user language and interface.

We expect to use **OpenMath** to communicate data between the UI and the computation server. Additionally, the language of communication must **encode commands/errors** and **manage state**, both seemingly outside the scope of OpenMath.

In the more distant future we hope for some convergence and cooperation with Singular and Macaulay while recognizing the usefulness and importance of the distinct identities of the projects.
CoCoA 4 will continue in parallel until CoCoA 5 is able to replace it.

The principal web site for CoCoA 4 is

http://cocoa.dima.unige.it

This site is mirrored in three places

http://www.physik.uni-regensburg.de/~krm03530/cocoa
http://www.reed.edu/mirrors/cocoa
http://www.mast.queensu.ca/ cocoa