

CoCoA

A system for  
**Computing in Commutative Algebra**

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# What is CoCoA?

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](#).

## Research for CoCoA

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.

## Research with CoCoA

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 and Education

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 Macintoshes.
- ◇ 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

# Architecture

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

## Current state of CoCoA 5

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**

## Conclusion: much still to do

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 web sites

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>