# CABRI-Graph: A Tool for Research and Teaching in Graph Theory

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**Abstract.** We present the graph visualization and computional system CABRI-Graph, an interactive tool that can be used by student, teacher or researcher. The user may construct graphs interactively, select algorithms or graph transformations from a menu, and view the results directly on the screen

## 1. Introduction

When studying a practical problem one have often to draw a symbolic representation of the problem which may allow a better visualization and then a better understanding of the situation. A natural way is to represent the interactive objects of the situation by points and lines expressing relationships. That is the graph representation. As practical problems have always complicated representations, the use of some graph software becomes unavoidable.

There exist three categories of graph software : systems like GraphBase [6] which consist of a library of graph algorithms, systems like EDGE[7] or DaVinci [4] concentrate on graph visualization and editing, and system like GraphEd [5] which is a combination of an editor and a library of algorithms, and also set of graph layout algorithms.

The goal of the CABRI-Graph[1] software is to create interactively a graph. CABRI-Graph [1, 2] allows you to handle graphs as you would do it on paper, with all the facilities and power a microcomputer can bring. The main interest of CABRI-Graph ("CAhier de BRouillon Interactif", i.e. "computerized sketchpad") lies in its highly interactive behaviour.

## 2. CABRI-Graph

CABRI-Graph consists essentially of a graph editor, associated with a toolkit allowing different computations, such as evaluation of graph invariants (chromatic number, stability number, chromatic polynomial, ...) or the performing of some classical transformations. Transformations upon graph drawing are also available (planar drawing of planar graphs, graph embedding, ...).

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[1] CABRI-Graph and related documents are available by anonymous ftp from the site ftp.imag.fr, /pub/Cabri/ .

CABRI-Graph is structured as two parts, namely the interactive interface and the toolkit, which can be subdivided in three subparts: random generator of graphs, graph transformations and graph computations.

## 2.1 The User Interface

CABRI-Graph conforms strictly to the interface standards recommended by Apple Macintosh. CABRI-Graph manages a so called graph-clipboard of its own which can be edited as any other graph window. The graph-clipboard allows to exchange graphs in picture format with other text processing or drawing sofware (MacDraw, MacPaint, MacWrite, Word, ...).

All operations are menu, mouse or key and mouse driver. Working window has a menu bar, and there are keyboard shortcuts for frequently used commands. We have tried to make the user interface as easy as possible; it takes a few minutes to learn the basic commands of CABRI-Graph. The graphs may have an unlimited number of vertices and edges. Only memory capacity of hardware machin can stop the size of the graph.

## 2.2 The Toolkit

A number of actions, transformations or computations may be applied to a graph and are obtained through the menus; each one concerns the graph itself or the subgraph induced by the selected vertices. Meanwhile it is already possible to perform interesting experiments with the random generator of graph.

### 2.2.1 Random Graph

The random generator of graphs [2], satisfying a number of parametrizable properties (fig. 1) has been specially developped to allow the user (student, teacher, researcher in graph Theory, ...) to experiment with theorems: one may also invalidate a hasty conjecture, or on the contrary, bring some support to a more elaborate one.

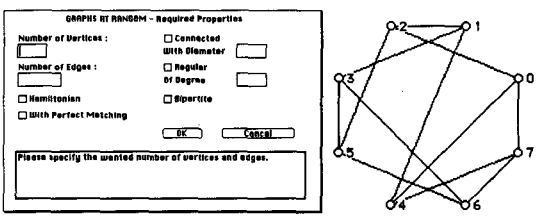


Fig. 1. Random generator of graph.

### 2.2.2 Transformation and Computation

The product of graphs is often difficult to visualize. CABRI-Graph propose a tool for computing three types of product: cartesian product, cross-product and complete product of the graph on the screen and the graph on the clipboard.

It can be interesting to use CABRI-Graph to draw nice figure for a publication. This work can be made extremely easy by taking advantage of different features of

the editor CABRI-Graph, such as the random generator and the operations product and identify.

For instance CABRI-Graph includes the construction of cliques, of line-graphs, the computation of connected components and the other basic properties and invariants.

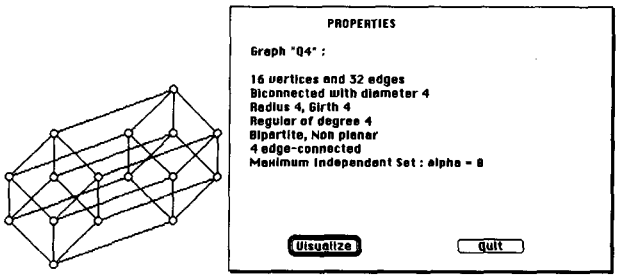


Fig. 2. Q4 graph and properties.

CABRI-Graph also propose different graphical representations designed to emphazise some properties of the graph (fig. 2). For instance, the 4-cube in figure 2 have been drawn by "Product by K2" (the "Transform" menu) with an edge as basis. The "Functions" menu makes you able to compute and visualize the properties of the drawn graph.

## 3. The Editor or Graphical Representation of Graph

The objects manipulated by CABRI-Graph are sets of points together with edges inter-connecting them and the edges. The incidence relation between vertices and edges is not the only mathematical structure involved, but also the geometrical aspects (the edges can be lines or curves).

CABRI-Graph offers various options to customize the appearance of vertices and edges :

**Vertex** Vertex can have arbitrary shape ( square, circle or triangle ), arbitrary size and arbitrary color - fundamental eight color without black; the black color is to represent a selected vertex.

**Edge**[2] Edge can have also arbitrary shape ( line or curve), arbitrary size and arbitrary color - fundamental eight color without white; the white color is to represent a selected edge.

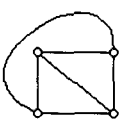

Fig. 3. A graph with a curved edge.

[2] We have introduced in CABRI-Graph the possibility to draw curved edges and thus multiple edges. To allow all different forms of edges (loops, laces, circle arcs, ...), we use cubic Bézier curves which permit appropriate forms [3].

**Label** CABRI-Graph supports arbitrary labels for vertices. There is no restriction on the contents or the lenght of the labels. Label is placed automatically, but the user can place it elsewhere. Furthermore, labels may have arbitrary fonts, size, and style.

The command "Edit Vertices ..." is more than simple labeling of vertices. The dialog window appear. We can edit shape and size of the vertex, and also string, font, size and place of the label. A partial view of your graph is displayed. The vertex you are editing is pointed out.

CABRI-graph saves graphs as ASCII text files. Thus you can exchange graphs written in the same format with another system like UNIX.

## 4. Conclusion

CABRI-Graph has many usefull facilities as to manipulate, to visualize.graphs and properties, to compute graph invariants or graph products.

It has been extensively used as a support for teaching, and much more for research. CABRI-Graphes allow to elaborate conjectures or to elaborate proofs and part of proofs for them. The lay point is to check possible intermidiate step in the whole proof process.CABRI is an acronym for "CAhier de BRouillon Interactif" (interactive notebook). The project is developped at the Laboratoire de Structures Discrètes et de Didactique", IMAG (Grenoble Institute of Computer Science and Epllied Mathematics). CABRI-Graph is written in C and runs on AppleMacintosh.

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