



ISISLab

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Collaborative GeoGebra

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Overview

- ▶ What is a GeoGebra?
- ▶ CoFFEE
- ▶ Collaborative GeoGebra
- ▶ Architecture
- ▶ Conclusions

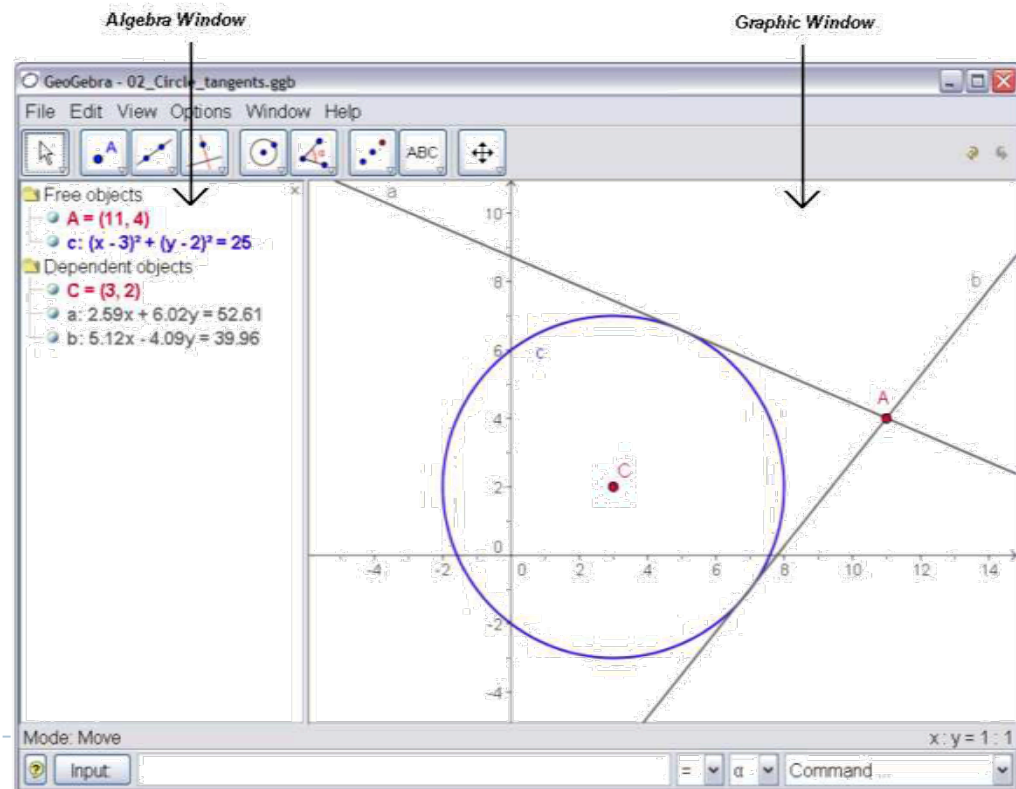


GeoGebra

- ▶ Is a single-user stand-alone mathematic software for schools
 - ▶ allows to construct points, vectors, segments, lines and conic sections as well as functions
 - ▶ Every time the user can change dynamically the construction

- ▶ **GeoGebra consists of:**

- ▶ A Graphic Window
- ▶ An Algebra Window
 - ▶ In which user can enter:
 - Algebraic input
 - Commands
 - Functions



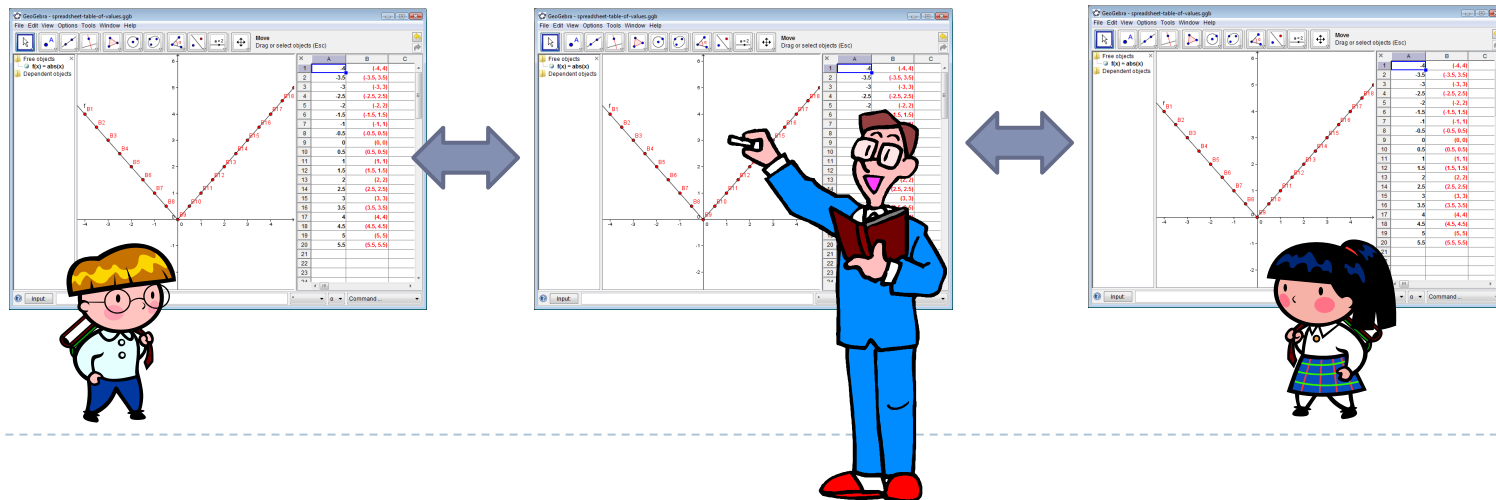
GeoGebra (2)

- ▶ implemented in java
- ▶ distributed as
 - ▶ Stand-alone application
 - ▶ Java applet to use in the browser
- ▶ Provides APIs to interact with the geometric construction
- ▶ open source project
- ▶ provided with GPL license



Our goal

- ▶ Design a collaborative real-time mathematics application
 - ▶ to support cooperative learning of mathematics and geometry
 - ▶ to enable multiple users to cooperate in parallel way on a shared mathematic workspace
 - ▶ Each user has a replica of both algebra and graphic window
 - ▶ Each user can add, delete and modify geometry construction (points, segments, lines etc.) in real time
 - ▶ Each user can see the changes in real-time



CoFFEE

- ▶ Is a suite of applications designed to support the collaborative learning in classroom
- ▶ Leverages on Eclipse platform
 - ▶ Each CoFFEE application is a Rich Client Application
- ▶ The main CoFFEE applications are
 - ▶ CoFFEE Controller: used by teacher to mediate the lesson
 - ▶ CoFFEE Discusser: used by students
- ▶ Distributed with EPL license



CoFFEE tools

- ▶ **Provides a set of collaborative tools**
 - ▶ Chat tool, threaded chat tool, positionometer, graphical tool
 - ▶ Implemented as Eclipse-based plug-ins
 - ▶ Integrated on the CoFFEE applications through the extension point mechanism inherited by Eclipse
 - ▶ In this way each developer can contribute with new tools without modification of existing applications
- ▶ **CoFFEE provides many services to the tools such as**
 - ▶ Communication service, server discovery, authentication, latecomers management

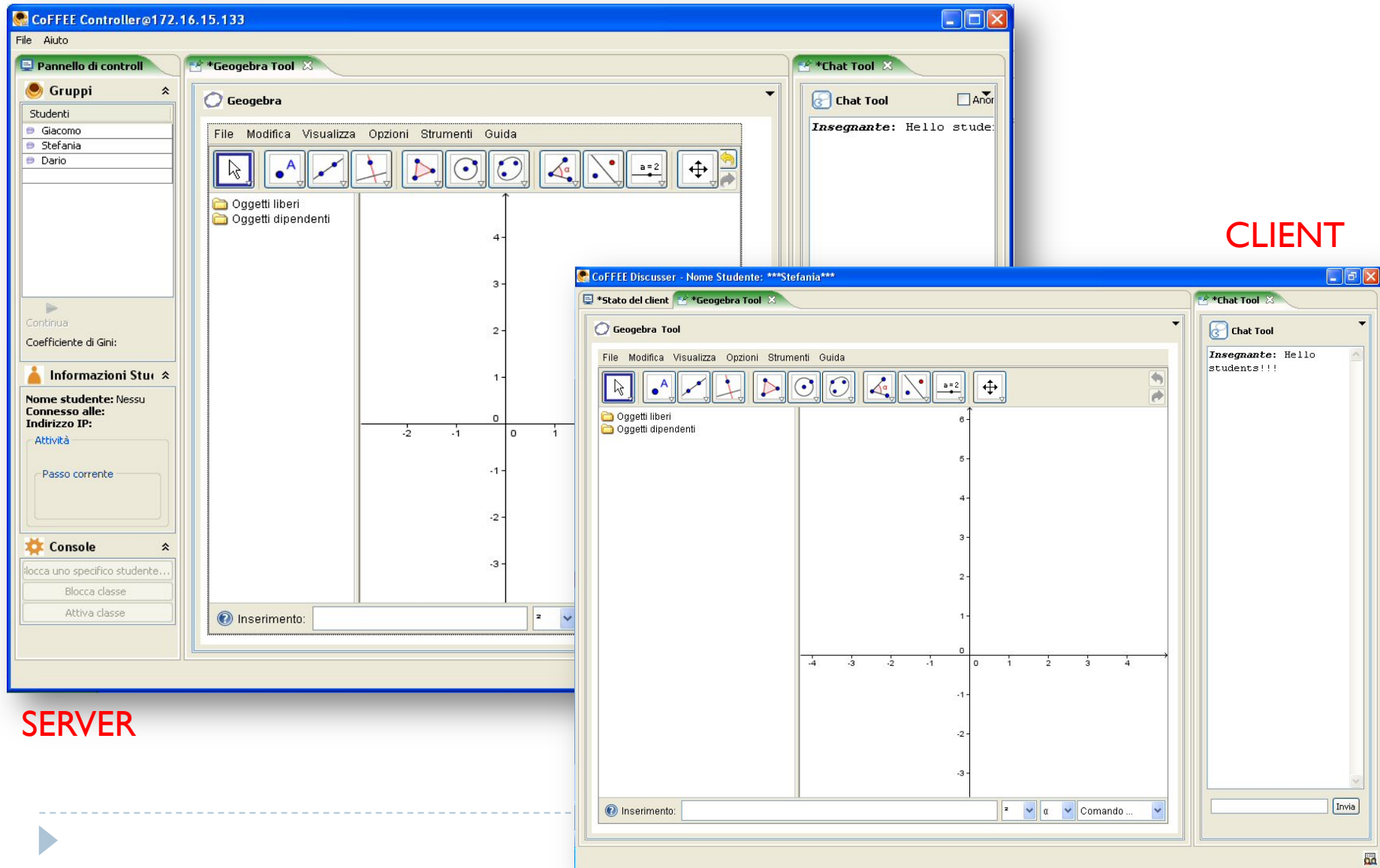


Collaborative GeoGebra tool

- ▶ We aim to introduce collaboration features in GeoGebra
- ▶ To make collaborative GeoGebra we leverage on CoFFEE suite
 - ▶ we define Collaborative GeoGebra as a CoFFEE Tool
 - ▶ preserving users familiarity with single-user version of GeoGebra
 - ▶ introducing collaborative functionalities without any modification of GeoGebra source code
 - ▶ To support successive versions of single-user application



1) Collaborative GeoGebra



SERVER

CLIENT

2) Server adds a circle

The screenshot displays the CoFFEE Controller interface. The main window is titled "CoFFEE Controller@172.16.15.133". It features a "Pannello di controllo" (Control Panel) on the left with sections for "Gruppi" (Groups), "Informazioni Stu" (Student Information), and "Console". The central area is the "Geogebra Tool" window, which shows a coordinate plane with a circle centered at (1, 1) and passing through points A(1, 1) and B(1, 0). The circle's equation is listed as $c: (x - 1)^2 + (y - 1)^2$. A red arrow points to the circle tool icon in the toolbar, and a red box highlights the circle on the graph. To the right is a "Chat Tool" window showing a message from "Insegnante: Hello stude:". At the bottom, the "SERVER" and "CLIENT" labels are visible, indicating the roles of the two windows.

3) All clients update their construction

The image displays two windows from the CoFFEE system. The top window, titled "CoFFEE Controller@172.16.15.133", is the server interface. It features a "Pannello di controllo" (Control Panel) on the left with sections for "Gruppi" (Groups) listing students Giacomo, Stefania, and Dario; "Informazioni Stu" (Student Information) showing "Nome studente: Nessu" and "Indirizzo IP:"; and "Console" with buttons for "Blocca classe" and "Attiva classe". The main area shows a "Geogebra Tool" window with a coordinate plane. The tool's toolbar includes icons for various geometric constructions. The object list on the left shows "Oggetti liberi" with $A = (1, 1)$, "Oggetti dipendenti" with $B = (1, 0)$, and a circle $c: (x - 1)^2 + (y - 1)^2 =$. The graph shows a circle centered at $A(1, 1)$ passing through $B(1, 0)$. The bottom window, titled "CoFFEE Discusser - Nome Studente: ***Stefania***", is a client interface. It shows the same "Geogebra Tool" window, but the circle equation is updated to $c: (x - 1)^2 + (y - 1)^2 = 1$. The graph shows the same circle construction. A "Chat Tool" window is open in the top right of the client, displaying "Insegnante: Hello students!!!". A red arrow points from the text "All clients update their construction" to the updated circle equation in the client's Geogebra tool. The word "SERVER" is written in red at the bottom left, and "CLIENT" is written in red at the top right.

SERVER

CLIENT

4) A client adds a line

SERVER

CLIENT

CoFFEE Controller@172.16.15.133

Pannello di controllo

Gruppi

Studenti

- Giacomo
- Stefania
- Dario

Continua

Coefficiente di Gini:

Informazioni Stu

Nome studente: Nessu
Connesso alle:
Indirizzo IP:
Attività

Passo corrente

Console

Blocca uno specifico studente...

Blocca classe

Attiva classe

Geogebra

File Modifica Visualizza Opzioni Strumenti Guida

Oggetti liberi

- A = (1, 1)

Oggetti dipendenti

- B = (1, 0)
- c: $(x - 1)^2 + (y - 1)^2 =$

Inserimento:

CoFFEE Discussor - Nome Studente: ***Dario***

Stato del client

Geogebra Tool

File Modifica Visualizza Opzioni Strumenti Guida

Oggetti liberi

- A = (1, 1)

Oggetti dipendenti

- B = (1, 0)
- C = (0, 3)
- D = (3, 0)
- a: $x + y = 3$
- c: $(x - 1)^2 + (y - 1)^2 = 1$

Inserimento:

Chat - Puoi usare questo tool per comunicare con gli altri utenti nel gruppo

Chat Tool

Insegnante: Hello students!!!

Invia

5) Server updates its construction

The image shows a screenshot of the CoFFEE Controller interface, which is divided into several panels. On the left is the 'Pannello di controllo' (Control Panel) with sections for 'Gruppi' (Groups), 'Informazioni Stu' (Student Information), and 'Console'. The main area is the 'Geogebra Tool' window, which displays a coordinate plane with a circle and a line. The circle is centered at (1, 1) and has a radius of 1. The line is defined by the equation $x + y = 3$. The intersection points of the circle and the line are labeled A, B, C, and D. The Geogebra toolbar is visible at the top of the tool window, and a red arrow points to the 'Move' tool icon. The 'Chat Tool' window is also visible, showing a message from 'Insegnante: Hello stude:'. The interface is labeled 'SERVER' and 'CLIENT'.

SERVER

CLIENT

Steps for creation of Collaborative GeoGebra

- ▶ **First step:**

- ▶ creation of CoFFEE tools embedding Geogebra

- ▶ **Second step**

- ▶ integration of GeoGebra into the tools

- ▶ **Third step**

- ▶ Managing interaction between the CoFFEE tools and the GeoGebra applet
 - ▶ For the introduction of collaborative functionalities
- ▶ Synchronization among server and clients



CoFFEE tools embedding GeoGebra

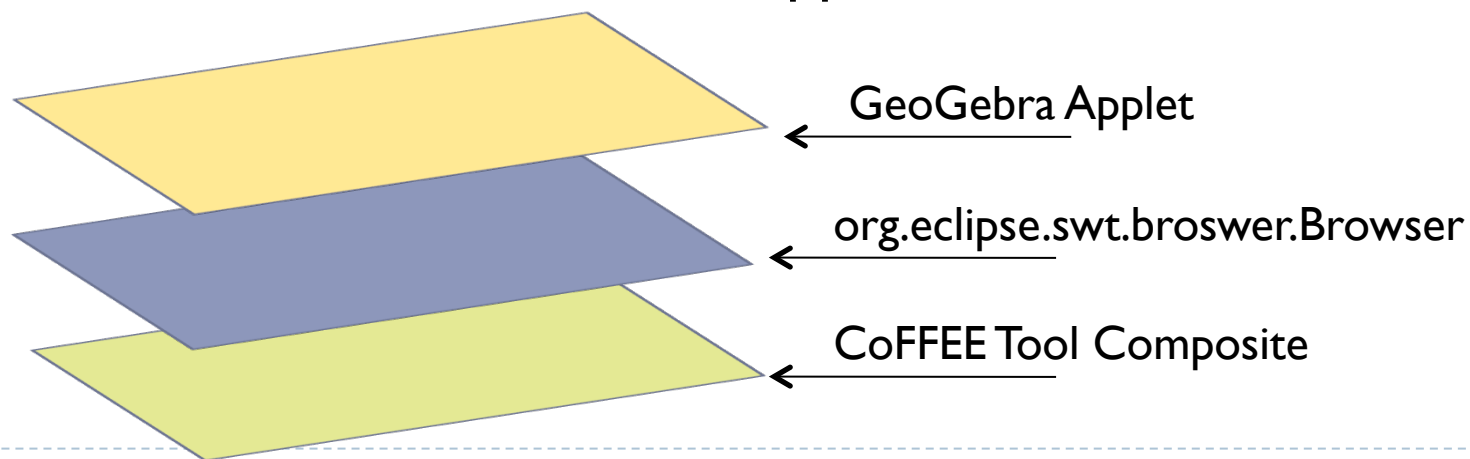
- ▶ **Client/server architecture**
 - ▶ each client has a replica of the mathematic workspace
 - ▶ the input of each client is passed to server which forwards it to all other clients

- ▶ **Plugins to embed Geogebra in a CoFFEE tool**
 - ▶ GeoGebra Tool Server side
 - ▶ GeoGebra Tool Common
 - ▶ GeoGebra Tool Client side



Integration of GeoGebra in a CoFFEE tool

- ▶ There are mainly two way for integration
 - ▶ Embed Swing GeoGebra panel into SWT GUI of CoFFEE tool
 - ▶ Use of GeoGebra applet
- ▶ For incompatibility between EPL and GPL license
 - ▶ CoFFEE is distributed with EPL license
 - ▶ GeoGebra is licensed with GPL license
- ▶ We decide to integrate GeoGebra Applet into CoFFEE tools
- ▶ The idea is to load GeoGebra applet into SWT Browser widget



Interaction with GeoGebra Applet

- ▶ We interact with GeoGebra Applet via provided APIs:
 - ▶ Methods to get and set GeoGebra objects (points, lines, etc.)
 - ▶ Methods to register JavaScript functions as listener
- ▶ On all the clients we register listeners to receive notifications of users' events
 - ▶ creation, deletion, moving or changing of properties
 - ▶ For each event the appropriate listener creates a message containing all the required information and sends it to the server through the CoFFEE communication service
- ▶ All listeners are called after then the user has completed the operation



Synchronization among server and clients

- ▶ We must guarantee synchronization among all replicas
- ▶ Client/server architecture
 - ▶ Allows to centralize the synchronization of events
 - ▶ And manage all events in order of arrival
- ▶ When the server receives a message from client
 - ▶ Extract information about event
 - ▶ Execute event on server to update GeoGebra construction server side
 - ▶ Sends a message to all clients
 - ▶ Included the client that originated the event
 - ▶ All the clients update their GeoGebra construction



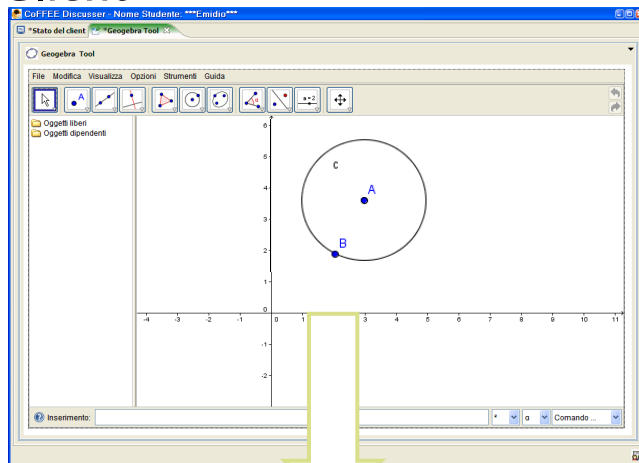
Synchronization issue

► Synchronization issue on the creation events

- The user creates an object
- Listener on the client receives the related notification after the object has been created
- For this reason the listener immediately delete the created object
- And then it sends a message to server with information on creation event
- Server updates its construction and forwards the events to all the clients
 - Included the creator, where the object has been deleted by the listener

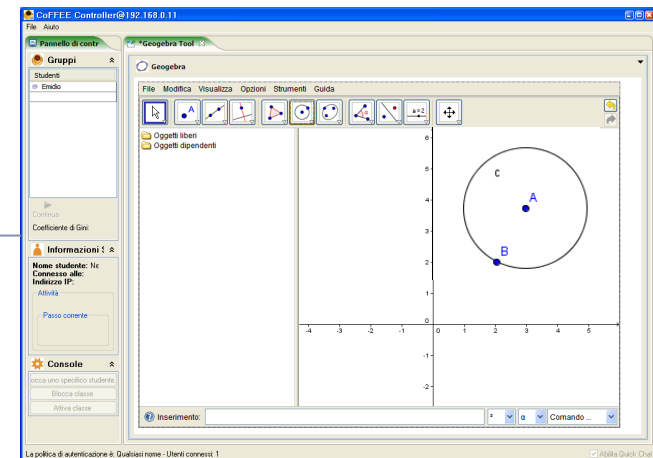
This would break the
guarantess of synchronization
on the server

Client



Messaggio

Server



Synchronization problem

- ▶ Collaborative GeoGebra is obviously multithread application
- ▶ In specific circumstances and under heavy load
 - ▶ GeoGebra throws a `CuncurrentModificationException`
 - ▶ This exception is within the applet
 - ▶ We believe that it could depend on the use of data structure which are not designed to be accessed by several threads



Conclusions

- ▶ Collaborative GeoGebra allows students to learn mathematic and geometry concepts in cooperative way
- ▶ The design of Collaborative GeoGebra has been supported by CoFFEE
- ▶ A remarkable consideration concern incompatibility between license EPL and GPL
 - ▶ We don't modify GeoGebra source code
 - ▶ We don't re-distribuite GeoGebra
 - ▶ We use GeoGebra applet and and load it from GeoGebra website

