

# Arcano: Case-Based Framework Documentation and their Example-Based Learning TIC2002-01961

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## Abstract

Object-oriented frameworks play an increasing role in the development of software applications, given that they are progressively becoming popular in general purpose class libraries, as well as in more specific domains.

One of the greatest problems related with the use of frameworks is the difficulty associated with learning to apply them. This project follows on from a previous one and concentrates on two aspects of this problem: the documentation of frameworks, on one hand, and providing training in the use of frameworks, on the other. With respect to documentation, the main aim is to develop a collaborative environment for defining and sharing 'recipes' which exemplify interesting uses of the framework. The use of examples establishes the connection with the pedagogical aims of the project. In this sense, we propose the use of case-based teaching techniques for framework programming tutoring. To achieve this, a problem solving environment must be designed in which the student can be confronted with specific examples to guide his learning process.

As supporting technology for the two aims above, previous work on the integration of Case-Based Reasoning (CBR) and explicit representation of knowledge as ontologies will be continued. On one hand, the existing model and associated tools will be further developed, and on the other their application will be tested on the domain of case-based teaching - which we consider particularly suitable.

**Keywords:** Software Reuse, Example-Based Teaching, Case-Based Reasoning

## 1 Arcano Goals

Arcano is a follow up of a previous project on framework reuse (Applying Artificial Intelligence Techniques to Object-Oriented Framework Reuse, TIC98-0733). Arcano initial planification was the one shown in Figure 1 where the tasks were organized around three main lines of research:

**Framework Documentation** Since this project built on top of a previous one where Smalltalk was the language for the systems being analyzed, we proposed to port the available tools

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The first implementation in LISP/LOOM of our architecture CBR<sub>Onto</sub>/COLIBRI had been useful during the last few years for testing and prototyping CBR systems. However, it was not very usable outside of our research group, and, therefore, in order to open these ideas to a wider community of CBR developers, we planed to evolve this architecture to fulfill modern software engineering standards. At the same time the underlying ideas should keep evolving and new supporting tools should be developed.

## 2 Technical Results

Next subsections describe the main results along the three lines of research mentioned before. In general, the actual results pretty much agree the initial schedule and we can not mention any relevant difficulty in the project development.

### 2.1 CBR and Ontologies

The main contribution along this line is jCOLIBRI [1] an evolution of COLIBRI that incorporates, in a distributed architecture, a description logics (DLs) engine, GUI clients for assembling a CBR system from reusable components and an object-oriented framework in Java. This architecture separates the domain ontologies (based on the DLs connector) from the CBR ontology (CBR<sub>Onto</sub>) and the task/method library.

In order to alleviate framework instantiation effort, jCOLIBRI features a semiautomatic configuration tool that guides the instantiation process through a graphical interface. This interface is dynamically built to reflect the actual contents of the task/method ontology, relying on the XML files describing task and method constraints and profiting from reflection facilities implemented in Java. The system has been recently released as an open source effort (<http://jcolibri-cbr.sourceforge.net/>) and will hopefully benefit from the input of the CBR community.

In the meanwhile, COLIBRI keeps evolving with new methods. In [8] we describe a generic method to solve the case retrieval task. This method is based on Formal Concept Analysis and takes into account the adaptation cost to retrieve the best candidates.

Finally, some preliminary work has been done on the incorporation of large ontologies [3] and the adoption of the last standards for knowledge representation in the Semantic Web [2]. This results should arise opportunities for technology transfer, in particular connected to natural language processing.

### 2.2 Framework Documentation

Following the original plan, the active recipes approach has been applied to frameworks in Java. The framework of choice for making the experiments has been JHotDraw, a two-dimensional graphics framework for structured drawing editors that is written in Java. This framework is specially well suited for the proposed approach because it has been carefully built around design patterns in order to exemplify good design principles. Tools have been developed to assist the user in domain analysis and semiautomatically build a domain model from the available documentation and through reverse engineering of the framework source code [11].

The case-based documentation cycle is closed with a mixed-initiative adaptation engine based on source code templates that allows to incorporate new recipes [12].

Regarding collaborative use of shared cookbooks, the work has been oriented into the definition of consensual conceptualizations of the domains that could support a common understanding among the users. A methodology for building lightweight ontologies has been developed that integrates three combined approaches [16]: text processing techniques to build an ontology-based organization of the Case Base and to populate it with cases extracted from structured documents [14]; a two-layered knowledge representation with an easy graphical language based on conceptual maps and an internal layer with a formal representation language [15]; and a refinement cycle to built the ontology in an incremental way.

The work on user modelling has been, first, on the automatic generation of personalized summaries based on user experience [7], and, second, on applying relevance feedback techniques to improve retrieval of textual information [4] and measure its effectiveness [6] in terms of a previously defined test collection [5]. We think that these results in the domain of personalized news delivery will be easily applied to the problem of personalizing the access to a collection of textual recipes of framework documentation.

### 2.3 Example-Based Learning

After some initial work on more conventional approaches, the problem-solving environment we have chosen to experiment with is that of a simulation disguised as a 3D adventure game. Simulations have been used in education for some time now. In its conception, simulations served as an error-safe environment to train novices on the use of expensive or risky equipment. Nevertheless, the idea of learning-by-doing in a simulated environment is being pushed forward, opening new areas of training where there is no physical equipment to simulate. Areas such as engineering, social abilities, mathematics, to mention just a few. Games are a special kind of simulations with entertainment as goal. If a learning tool can be disguised as a game, then we get the motivation that the learning process requires.

This radical change in the kind of problem-solving environment also lead us to a temporal change on the domain. We felt the need to try this approach on the underlying working of the framework, and thus developed Javy (JAVa taught VirtuallY) [18]: an interactive adventure game to learn compilation and to understand the Java Virtual Machine (JVM). The student is symbolized as an avatar that interacts with the objects in a 3D world that is a metaphorical representation of the JVM. The system proposes exercises to the student as source code in Java that must be compiled and executed in the virtual world. Javy himself (see Figure 2) is an animated pedagogical agent who supplies hints to the student. This settlement opens opportunities to explore the power of simulations in game disguise as learning-by-doing environments, that, up to now, has led us to analyze the synergies between computer games and intelligent tutoring systems [17], conceptual blends as a formalization of metaphors [26], and natural language interaction in virtual environments [23].

Regarding natural language generation, the main effort has been applied to discourse generation, i.e., given a number of information items and a particular context what is the best way to express that information in natural language. Case-based approaches to story plot generation has been explored [9], using fairy tales as domain, and employing jCOLIBRI for prototype development. This approach profits from the formal representation of an ontology of



Figure 2: The student is approaching Javy to ask him a question.

narrative primitives [25] and can be augmented with mixed-initiative techniques that interleave the system and the user when building a story [24].

In parallel with the game-based initiative, and based on several state of the art reviews [13, 19] about teaching programming, we have been working on the definition of a generic architecture and a methodology for building example-based learning systems for frameworks [20, 22, 21]. This effort should guide the evolution of Javy.

### 3 Arcano Results

Regarding publications the project so far has produced 25 papers published in international (15) and national (2) conferences, as well as international workshops and symposia (7) and one technical report. These publications are included in the References Section below.

In the original proposal there were 6 PhD students and 3 more have been incorporated to the project in the first two years. 1 thesis has been finished and 3 more should be presented before the end of the project.

Regarding technology transfer we signed on May 2004 a contract (*artículo 83*) with Bull for the analysis of the viability of JoNAS, an open source application server, to the development of knowledge management systems in the European Space of Higher Education. This project is pushing the technical limits of jCOLIBRI and should serve as a real world test-bed for the proposed integration of CBR and ontologies.

The collaboration with the Creative Systems group from the *Departamento de Engenharia Informática* in the University of Coimbra has resulted in a grant for research mobility from the Spanish government through the programme *Acciones Integradas de Investigación Científica y Técnica del Ministerio de Ciencia y Tecnología*. Along this line of research, a proposal for FET Open (Call identifier: FP6/2002/IST/C) has been presented in 2004 with six more European partners under the title “Casting the net of Computational Creativity over European Science

and Technology”.

From August 30th to September 2th 2004, we have organized in the Faculty of Informatics of the Complutense University of Madrid the 7th European Conference on Case-Based Reasoning. ECCBR is the premier international forum for researchers and practitioners of CBR in the years interleaving with the biennial international counterpart ICCBR. During the conference we present jCOLIBRI to the community what resulted on proposals for collaborations from other research groups working on knowledge intensive CBR.

Finally, we have developed the program for a Master of Computer Games Development that we'll be teaching in the Complutense University of Madrid from November 2004 to June 2005. The Master has been designed in collaboration with Pyro Studios, which contributes its experience in the development of world-famous games (the Commandos saga) and offers the opportunity of incorporating some of the graduates into its crew. This Master will increase the social impact of the research group and should provide new opportunities for technology transfer.

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