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A MULTI-LAYER BASED ARCHITECTURE FOR THE DEVELOPMENT OF AN OPEN SOURCE CAD/CAM INTEGRATION VIRTUAL PLATFORM

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Abstract. *This article proposes a n-layer architechture, with a web client as a front-end, for the development of a virtual platform for process simulation on CNC machines. This Open-Source platform includes a CAD-CAM interface drawing primitives, and then used to furnish a CNC program that triggers a touch-screen virtual simulator. The objectives of this project are two fold. First, an educational component that foster new alternatives for the CAD-CAM/CNC learning process in undergrad & grade schools and technical and technological institutes emphasizing in the development of critical skills, discussion and collaborative work. The second objective puts together a research & technological component that will take the state of the art in CAD-CAM integration to a new level with the development of optimal algoritms and virtual platforms, on-line availability, that will pave the way for the long-term goal of this project, that is, to have a visible and active graduate school in Ecuador and a world wide Open-Innovation community in the area of CAD-CAM integration and operation of CNC machinery. The virtual platform, developed as a part of this study delivers: (1) improved trainning process of students, (2) creates a multidisciplinary team and a collaborative work space that will push the new generation of students to face future technological challenges, (3) implement industry standards for CAD/CAM, (4) a platform for the development of industrial applications. A protoype of this system was developed and implemented in a network of universities and technological institutes in Ecuador.*

1 INTRODUCTION

Manufacturing is a transformation process by which raw materials are converted into finished products with a market value, by a combination of labor, machinery, special tools and energy. Tools and machinery play a key role in the technological development of the world to the point that the rate of development of machine tools is an indicator of industrial development.

Complexity in the manufacturing process and increasing market demand for lower prices and stock led to the development of CNC (i.e. Computer Numerical Control). CNC is a manufacturing automation (i.e. programable) method that delivers important factors such as accuracy, speed, flexibility, operational reliability and increased industrial safety during the manufacturing process. By using this coded instructions, all actions of a machine or mechanism are controlled by a sequence of operations and movements (path tool, depth of cut, change tools, etc.) previously established by the programmer[1]. CNC code is based on the EIA 267-C standard and became as a standard itself for the integration of CAD, CAM and CAE on high performance computing environments.

Now a day, commercial mechanical CAD/CAM packages provide a rather low level of interaction with user needs[2]. On the other hand, the Open Source Development Model open up dominant proprietary software and

[1] P. N. RAO, Cad/Cam: Prin & Appl 3E, New Delhi, Tata McGraw-Hill Education, 2010. 784 p.

[2] Posinasetti Nageswara Rao (2004), CAD/CAM: Principles and Applications, Tata McGraw-Hill Education, 735 p.

brings collaborative work and community needs to the scene to strengthen the capabilities of current available CAD-CAM/CNC integration tools.

Several efforts are currently conducted towards the development of more efficient integration platforms on Open Environments[3]. However, technologies and methodologies for software development on Internet[4] are also an active area of research and development that brings new programming paradigms, code portability and flexibility with numerous applications in other fields. Within this context, a fundamental question arises and is answered in this project:

Is it possible to use a multi-layered platform to integrate CAD/CAM procedures and deliver a more efficient and accessible application under the concept of Open Innovation?

The answer to this question is, step by step, given trhoughout this paper. A web access CAD viewer for interacting with the users trhough Internet, a production environment with tools to support the development of CAM models that interface with a CNC code generator is available as standalone application but also in a corporate computational plataform (i.e. CEDIA multimedia center) to spread the educational impact of this project.

2 SOFTWARE ARCHITECTURE FOR CAD/CAM INTEGRATION

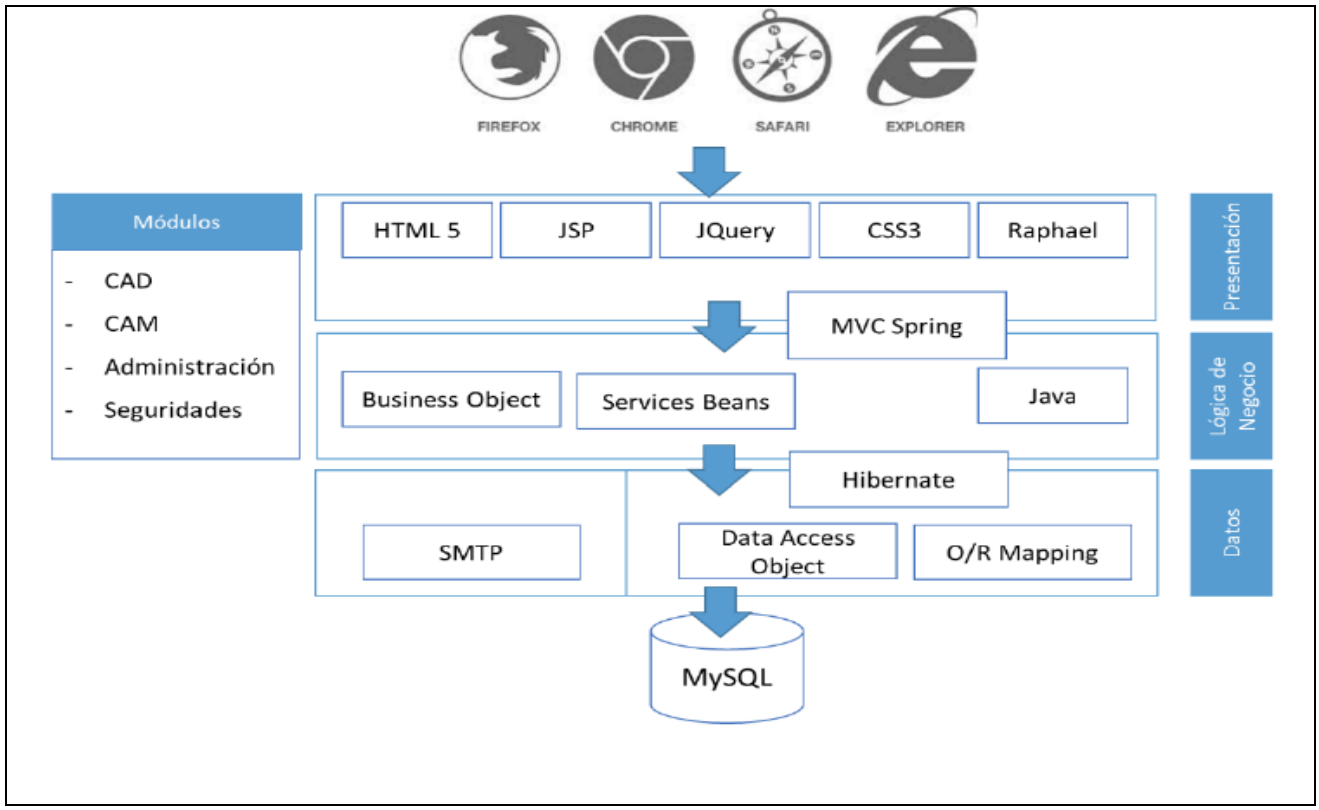

Figura 1. A n-layered architecture with web client for the development of a CAD/CAM OpenSource platform.

1.1 The n-layer architecture

The CAD/CAM web application is designed on Java Servlet technology. It has two web clients: (1)

[3] Tien-Chien Chang, Richard A. Wysk, Hsu-Pin Wang (2006), Computer-aided manufacturing, Pearson Prentice Hall, 670 p.

[4] Mikell P. Groover (2007), Automation, Production Systems, and Computer-integrated Manufacturing, USA, Prentice Hall, 815 p.

administration module, and (2) user module. The module for administration allows for security administration, maintenance catalogues control, etc. The user module constitutes the user interface; it is of the "Client Rich" type since high performance for user interaction, and graphics handling is required. The application is built on three layers described as follows:

1. **Front-End.** The front-end ecompases all the user interface of this application. It can be divided in the following components.

- **Views:** Web pages in JSP with tag libraries from Spring MVC that display user forms.
- **Controlers:** Controlers from SpringMVC that receive and process the user requests.
- **Models:** These are objects from the domain model.

2. **Bussiness Logic.** Collect all the complex processes that compose the application.

- **Service Layer: Controlers:** Implement and execute all process that belong to the business logic. It is also in charge of all the interactions with the Model Domain.
- **Model Domain Layer**: It contains all the components that encompass the conceptual structure of the applications. It uses traditions JaveBeans technology.
- **Data.** Implements the Data Model and the access to the data. It is built over ORM Hibernate.

1.2 Application components

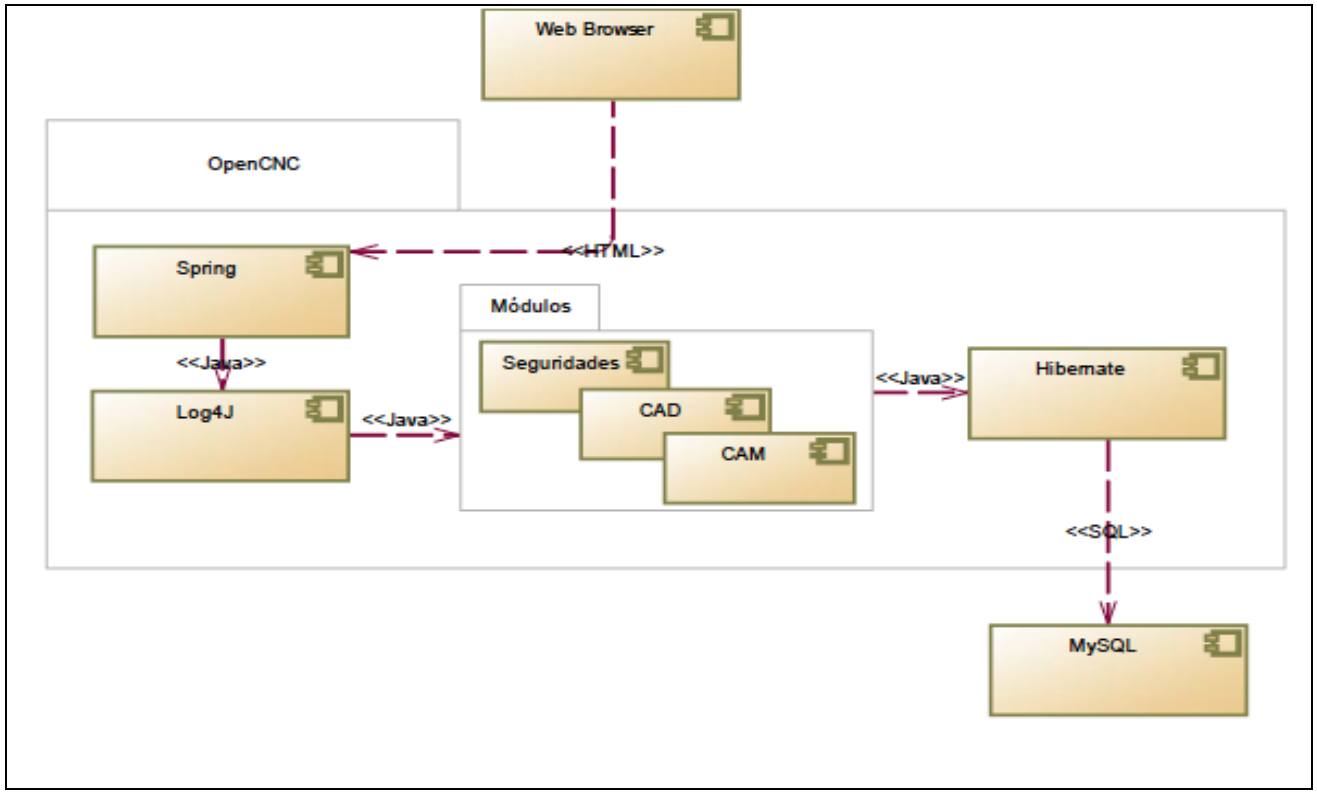

Figure 2. Application framework

Figure 2 shows the functionality and component of the CAD/CAM application. The links reflect the interactions between the different modules that compose the application. The application consists of three modules: (1) Security, (2) CAD, and (3) CAM, all of them access the data model designed for this application.

- **Module 1 (CAD):** It implements the business logic related to the generation of geometric entities or primitives that represent the target object for the manufacturing process. The CAD (Computer Aided Design), allows the designer to describe the geometry of parts, integrated circuits, assemblies, etc.

- **Module 2 (CAM):** It implements all the CAM operation specified by the user. It ends up with the generation of the CNC program that will serve as an input for the Virtual Simulator. The term CAM (Computer Aided Manufacturing) can be defined as the use of computerized systems for planning, management and control of the operations of a manufacturing plant by direct or indirect interface between the computer system and production resources.

- **Module 3 (Security/Administration):** It handles the security administration for the system.

- **Module 4 (Hibernate/MySQL):** It facilitates the mapping between the application object model and the relational data base.

11 RESULTS AND DISCUSSION

An integrated CAD -CAM platform is available in an Open Environment. Based on primitives used to describe the geometry of an object, a CNC program can be generated. The program is then used as an input for the virtual simulator implemented on a touch-screen system to let the user visualize the operation of CNC machines and tools. This virtual laboratory has been successfully implemented in Ecuadorian universities and technological institutes to facilitate the training on manufacturing processes of students and professionals.

In addition, the platform is being used by a group of researchers as a base line for further developments related to high performance computing, and artificial intelligence algorithms for CAD-CAM integration
A Network of researchers, instructors, graduate and undergraduate students in New Manufacturing Technologies that integrates interdisciplinary research can be regarded as an important output of this research. Project.

The high cost of CNC tools and machines is an obstacle for educational institutions of developing countries to include this type of equipment in the training process of students. Virtual simulators and laboratories, like the one implemented in this project, generate a profound impact in the learning process of mechanical engineers and technicians of these countries. In addition to that, the industrialization process and technological dependence of developing countries can be shortened with these type of Open Source and Open Innovation environments.

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REFERENCES

[1] Blanco J., Sanz F., (2002), *CAD-CAM Gráficos Animaciones y Simulación por Computador*, Ediciones Paraninfo, España, 232 p.

[2] Kundra T. K., (1993), *Computer Aided Manufacturing*, New Delhi, Tata McGraw-Hill Education, 417 p.

[3] Mikell G., (2007*), Fundamentos de Manufactura Moderna*, McGraw-Hill, México, 347 p.

[4] Mikell P., (2007), *Automation, Production Systems, and Computer-integrated Manufacturing*, Prentice Hall, USA, 815 p.

[5] Posinasetti R., (2004*), CAD/CAM: Principles and Applications*, Tata McGraw-Hill Education, 735 p.

[6] Rao P. N., (2010), *CAD/CAM: Prin & Appl 3E*, New Delhi, Tata McGraw-Hill Education, 784 p.

[7] Sanz F., Blanco J. (2007), *CAD-CAM Animación y Simulación por Computador*, Ediciones Paraninfo, España, 232 p.

[8] Tien-Chien C.,, Richard A. Wysk, Hsu-Pin W., (2006*), Computer-aided manufacturing*, Pearson Prentice Hall, 670 p.