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Computational Science and Its Applications – ICCSA 2011

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International Conference
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Volume Editors

Beniamino Murgante
Basilicata University Potenza, Italy
E-mail: beniamino.murgante@unibas.it

Osvaldo Gervasi
University of Perugia, Italy
E-mail: osvaldo@unipg.it

Andrés Iglesias
University of Cantabria, Santander, Spain
E-mail: iglesias@unican.es

David Taniar
Monash University, Clayton, VIC, Australia
E-mail: david.taniar@infotech.monash.edu.au

Bernady O. Apduhan
Kyushu Sangyo University
Fukuoka, Japan
E-mail: bob@is.kyusan-u.ac.jp

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Preface

These multiple volumes (LNCS volumes 6782, 6783, 6784, 6785 and 6786) consist of the peer-reviewed papers from the 2011 International Conference on Computational Science and Its Applications (ICCSA 2011) held in Santander, Spain during June 20-23, 2011. ICCSA 2011 was a successful event in the International Conferences on Computational Science and Its Applications (ICCSA) conference series, previously held in Fukuoka, Japan (2010), Suwon, South Korea (2009), Perugia, Italy (2008), Kuala Lumpur, Malaysia (2007), Glasgow, UK (2006), Singapore (2005), Assisi, Italy (2004), Montreal, Canada (2003), and (as ICCS) Amsterdam, The Netherlands (2002) and San Francisco, USA (2001).

Computational science is a main pillar of most of the present research, as well as industrial and commercial activities and plays a unique role in exploiting ICT innovative technologies. The ICCSA conferences have been providing a venue to researchers and industry practitioners to discuss new ideas, to share complex problems and their solutions, and to shape new trends in computational science.

Apart from the general tracks, ICCSA 2011 also included 31 special sessions and workshops, in various areas of computational science, ranging from computational science technologies to specific areas of computational science, such as computer graphics and virtual reality. We accepted 52 papers for the general track, and 210 in special sessions and workshops. These represent an acceptance rate of 29.7%. We would like to show our appreciations to the Workshop and Special Session Chairs and co-Chairs.

The success of the ICCSA conference series, in general, and ICCSA 2011, in particular, is due to the support of many people: authors, presenters, participants, keynote speakers, Session Chairs, Organizing Committee members, student volunteers, Program Committee members, International Liaison Chairs, and people in other various roles. We would like to thank them all. We would also like to thank Springer for their continuous support in publishing ICCSA conference proceedings.

June 2011

Osvaldo Gervasi
David Taniar

Message from the ICCSA 2011 General Chairs

These five volumes contain an outstanding collection of refereed papers selected for the 11th International Conference on Computational Science and Its Applications, ICCSA 2011, held in Santander (Spain), June 20-23, 2011. We cordially invite you to visit the ICCSA website `http://www.iccsa.org` where you can find all relevant information about this interesting and exciting event.

ICCSA 2011 marked the beginning of the second decade of this conference series. Previous editions in this series of highly successful International Conferences on Computational Science and Its Applications (ICCSA) were held in Fukuoka, Japan (2010), Suwon, Korea (2009), Perugia, Italy (2008), Kuala Lumpur, Malaysia (2007), Glasgow, UK (2006), Singapore (2005), Assisi, Italy (2004), Montreal, Canada (2003), and (as ICCS) Amsterdam, The Netherlands (2002) and San Francisco, USA (2001).

As we enter the second decade of ICCSA, we realize the profound changes and spectacular advances in the world of computational science. This discipline plays a unique role in fostering new technologies and knowledge, and is crucial for most of the present research, and industrial and commercial activities. We believe that ICCSA has contributed to this change by offering a real opportunity to explore innovative approaches and techniques to solve complex problems. Reciprocally, the computational science community has enthusiastically embraced the successive editions of ICCSA, thus contributing to making ICCSA a focal meeting point for those interested in innovative, cutting-edge research about the latest and most exciting developments in the field. We are grateful to all those who have contributed to the current success of ICCSA with their continued support over the past ten years.

ICCSA 2011 would not have been made possible without the valuable contribution from many people. We would like to thank all session organizers for their diligent work, which further enhanced the conference levels and all reviewers for their expertise and generous effort which led to a very high quality event with excellent papers and presentations. We especially recognize the contribution of the Program Committee and Local Organizing Committee members for their tremendous support and for making this congress a very sucessful event.

We would like to sincerely thank our keynote speakers, who willingly accepted our invitation and shared their expertise through illuminating talks, helping us to fully meet the conference objectives.

We highly appreciate the University of Cantabria for their enthusiastic acceptance to host the conference on its main campus, their logistic assistance and additional financial support. The conference was held in the Faculty of Sciences of the University of Cantabria. We thank the Dean of the Faculty of Sciences, Ernesto Anabitarte, for his support before and during the congress, and for providing the venue of the conference and the use of all needed facilities.

ICCSA 2011 was jointly organized by the Department of Applied Mathematics and Computational Sciences and the Department of Mathematics, Statistics and Computation of the University of Cantabria, Spain. We thank both departments for their encouranging support of this conference from the very beginning. We would like to express our gratitude to the Local Organizing Committee for their persistent and enthusiastic work towards the success of this conference.

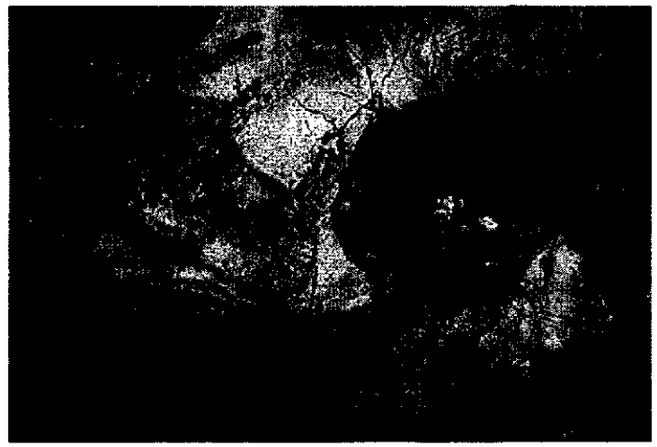
We owe special thanks to all our sponsors: the Faculty of Sciences, the University of Cantabria, the Municipality of Santander, the Regional Government of Cantabria and the Spanish Ministry of Science and Innovation, for their continuous support without which this conference would not be possible. We also thank our publisher, Springer, for their acceptance to publish the proceedings and for their kind assistance and cooperation during the editing process.

Finally, we thank all authors for their submissions and all conference attendants for making ICCSA 2011 truly an excellent forum on computational science, facilitating exchange of ideas, fostering new collaborations and shaping the future of this exciting field. Last, but certainly not least, we wish to thank our readers for their interest in these proceedings. We really hope you find in these pages interesting material and fruitful ideas for your future work.

June 2011

Andrés Iglesias
Bernady O. Apduhan

The Wisdom of Ancient Masters



In 1879, Marcelino Sanz de Sautuola and his young daugther María incidentally noticed that the ceiling of the Altamira cave was covered by images of bisons and other animals, some as old as between 25,000 and 35,000 years. They had discovered what came to be called the Sistine Chapel of Paleolithic Art. When the discovery was first made public in 1880, many experts rejected it under the belief that prehistoric man was unable to produce such beautiful and ellaborated paintings. Once their authenticity was later confirmed, it changed forever our perception of prehistoric human beings.

Today, the cave of Altamira and its paintings are a symbol of the wisdom and ability of our ancient ancestors. They remind us that our current technological development is mostly based on the work, genius and efforts of our predecessors over many generations.

The cave of Altamira (UNESCO World Heritage Site) is located in the region of Cantabria, near the city of Santander (ICCSA 2011 conference venue). The original cave is closed to the public for preservation, but conference attendees visited the "Neocave", an exact reproduction of the original space with all its cracks and textures and the permanent exhibition "The Times of Altamira", which introduces visitors to the prehistory of the peninsula and rupestrian art.

"After Altamira, all is decadence" (Pablo Picasso, famous Spanish painter)

ICCSA 2011 Welcome Message

Welcome to the proceedings of the 11th International Conference on Computational Science and Its Applications, ICCSA 2011, held in Santander, Spain.

The city of Santander is located in the self-governed region of Cantabria, on the northern coast of Spain between Asturias and the Basque Country. This beautiful region of half a million inhabitants is on the shores of the Cantabrian Sea and is crossed by a mountain range. The shores and inland valleys offer a wide variety of landscapes as a consequence of the mild, moist climate of so-called Green Spain. The coastal landscape of beaches, bays and cliffs blends together with valleys and highland areas. All along the coast there are typical traditional fishing ports and innumerable diverse beaches of soft white sand.

However, Cantabria's attractions are not limited to its natural treasures. History has provided a rich artistic and cultural heritage found in towns and villages that are outstanding in their own right. The archaeological remains and historic buildings bear the mark of a unique history starting with the world-famous Altamira cave paintings, a veritable shrine to the prehistoric age. In addition, there are remarkable remains from the Romans, the Mozarabic presence and the beginnings of the Reconquest of Spain, along with an artistic heritage of Romanesque, Gothic and Baroque styles. Examples include the Prehistoric Era (the Altamira and Puente Viesgo Caves), Roman ruins such as those of Julióbriga, medieval settlements, such as Santillana del Mar, and several examples of the civil and religious architecture of the nineteenth and twentieth centuries.

The surrounding natural landscape and the historical importance of many of its villages and buildings make this region very appealing for tourism, especially during the spring and summer seasons, when the humid, mild weather gives the region a rich and varied nature of woods and meadows. At the time of the conference, attendees enjoyed the gentle climate (with temperatures averaging 18-20 degrees Celsius) and the longest days of the year. They found themselves waiting for sunset at the beach at about 11 pm!

Capital of the autonomous region of Cantabria, the city of Santander is also a very popular destination for tourism. Based around one of the most beautiful bays in the world, this modern city is famous for its sparkling beaches of yellow sand and clean water, the hospitality of its people and the high reputation of its celebrated gastronomy, mostly based on fish and shellfish. With a population of about 200,000 inhabitants, Santander is a very safe city, with a vibrant tourist scene filled with entertainment and a high quality of life, matching the best standards in the world. The coastal side of the city boasts a long string of top-quality beaches and recreational areas, such as the Magdalena Peninsula, the Sardinero and Mataleñas Park. There are several beaches and harbors limiting the city on the northern side, toward the southern part there is the old city

center and a bit further on the green mountains. We proudly say that Santander is between the blue and the green.

The University of Cantabria (in Spanish, *the Universidad de Cantabria, UC*) is the only public university in Cantabria, Spain. It was founded in 1972 and is organized in 12 faculties and schools. With about 13,000 students and 1,000 academic staff, the University of Cantabria is one of the most reputed universities in the country, ranking in the highest positions of Spanish universities in relation to its size. Not surprisingly, it was selected as a Campus of International Excellence by the Spanish Government in 2009.

Besides the technical sessions and presentations, ICCSA 2011 provided an interesting, must-attend social program. It started with a Welcome Reception at the Royal Palace of the Magdalena (Sunday 19), the most emblematic building of Santander and also the most visited place in the city. The royal family used the palace during the period 1913–1930 as a base for numerous recreational and sporting activities, and the king sometimes also held government meetings at the property. Conference delegates had the wonderful opportunity to visit this splendid palace, enjoy the magnificent views and see some rooms where royalty lived. The Gala Dinner (Tuesday 21) took place at the Grand Casino, in the "Sardinero" area, a regal, 1920's building with large windows and spacious terraces offering superb views of the Sardinero beach. The Casino was King Alfonso XIII and Queen Victoria Eugenia's main place of entertainment during their summer holidays in the city between 1913 and 1930. The gala also included some cultural and musical events. Finally, a half-day conference tour (Wednesday 22) covered the "live museum" of the Middle Ages, Santillana del Mar (a medieval town with cobbled streets, declared "Site of Artistic and Historical Importance" and one of the best-known cultural and tourist centers in Cantabria) and the Altamira Neocave, an exact reproduction of the original Altamira cave (now closed to the public for preservation) with all its cracks and textures and the permanent exhibition "The Times of Altamira", which introduces visitors to the prehistory of the peninsula and rupestrian art.

To close the conference, attendees could join the people of Santander for St. John's day, celebrated in the night between June 23 and 24 to commemorate the summer solstice with bonfires on the beach.

We believe that all these attractions made the conference an unforgettable experience.

On behalf of the Local Organizing Committee members, I thank all attendees fot their visit.

June 2011

Andrés Iglesias

Message from the Chairs of the Session: 6th International Workshop on "Geographical Analysis, Urban Modeling, Spatial Statistics" (GEOG-AN-MOD 2011)

During the past few decades the main problem in geographical analysis was the lack of spatial data availability. Nowadays the wide diffusion of electronic devices containing geo-referenced information generates a great production of spatial data. Volunteered geographic information activities (e.g., Wikimapia, OpenStreetMap), public initiatives (e.g., spatial data infrastructures, geo-portals) and private projects (e.g., Google Earth, Microsoft Virtual Earth, etc.) produced an overabundance of spatial data, which, in many cases, do not help the efficiency of decision processes. The increase of geographical data availability has not been fully coupled by an increase of knowledge to support spatial decisions.

The inclusion of spatial simulation techniques in recent GIS software favored the diffusion of these methods, but in several cases led to mechanisms based on which buttons have to be pressed without having geography or processes in mind. Spatial modeling, analytical techniques and geographical analyses are therefore required in order to analyze data and to facilitate the decision process at all levels, with a clear identification of the geographical information needed and reference scale to adopt. Old geographical issues can find an answer thanks to new methods and instruments, while new issues are developing, challenging researchers for new solutions. This workshop aims at contributing to the development of new techniques and methods to improve the process of knowledge acquisition.

Conference themes include:

Geostatistics and spatial simulation
Agent-based spatial modeling
Cellular automata spatial modeling
Spatial statistical models
Space-temporal modeling
Environmental modeling
Geovisual analytics, geovisualization, visual exploratory data analysis
Visualization and modeling of track data
Spatial optimization
Interaction simulation models
Data mining, spatial data mining
Spatial data warehouse and spatial OLAP
Integration of spatial OLAP and spatial data mining
Spatial decision support systems

HProcessTOOL: A Support Tool in the Harmonization of Multiple Reference Models

César Pardo[1], Francisco Pino[1], Félix García[2], Francisco Romero Romero[2], Mario Piattini[2], and Maria Teresa Baldassarre[3]

[1] IDIS Research Group
Electronic and Telecommunications Engineering Faculty,
University of Cauca, Calle 5 No. 4 - 70.
Kybele Consulting Colombia (Spinoff)
Popayán, Cauca, Colombia
{cpardo,fjpino}@unicauca.edu.co
[2] Alarcos Research Group
Institute of Information Technologies & Systems,
University of Castilla-La Mancha, Paseo de la Universidad 4, Ciudad Real, España
{Felix.Garcia,FranciscoA.Romero,Mario.Piattini}@uclm.es
[3] Department of Informatics, University of Bari
SER&Practices, SPINOFF, Via E. Orabona 4, 70126, Bari, Italy
baldassarre@di.uniba.it

Abstract. If companies are to fulfil their business goals then they must implement more than one software process improvement or information technology management model. The heterogeneity of these models signifies that their harmonization in accordance with company goals has become a key initiative. It is therefore necessary to provide companies with suitable software tools which facilitate the implementation and management of the activities, methods, techniques and reference models involved in a harmonization project, thus allowing the harmonization to be properly carried out. This paper therefore presents the HProcessTOOL which guides harmonization projects by supporting specific techniques, and supports their management by controlling and monitoring the resulting harmonization projects. The tool has been applied in two case studies, and has allowed the work products, effort, time and roles involved in the harmonization projects, and the knowledge generated, to be correctly managed.

Keywords: Multi-model, Multiple, Reference models, Harmonization, Software Process Improvement, (SPI), Harmonization strategy, Software Tool.

1 Introduction

Various improvement methodologies such as IDEAL [1], PDCA [2], PmCOMPETISOFT [3] and Agile SPI-Process [4] have been defined to support the process improvement of enterprises, These methodologies have taken multiple reference models such as ISO 27001, ISO 9001, CMMI and ISO 90003 as their basis. Other models, such as ITIL [5], COBIT [6], RISK IT [7] and VAL IT [8], have also been defined to

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support Information Technology Management. The implementation and institutionalization of these approaches have allowed companies to improve, mature, acquire and institutionalise best practices and management systems, such as: (i) Information Security Management Systems (ISMS), (ii) Information Technology Governance Processes (IT Governance), (iii) quality management systems, or even those in much more specific domains such as (iv) software development, (v) software maintenance and (vi) operation.

Given that enterprises currently need to resolve various business and operative needs independently of their work areas, they are obliged to use more than one reference model at the same time. However, since each model defines its own structure of process entities, definitions and quality systems [9], this issue increases the complexity involved in the implementation of multi-models in a single organization. It also implies greater efforts, time and associated costs than a conventional SPI environment (which is characterized by its use of only one reference model). This type of environment accordingly requires a specialized technical infrastructure (tools and methodologies), which allows the harmonization of multiple reference models to be supported.

In the last four years several efforts have been made to define proposals which attempt to provide methodologies that support the harmonization of multiple models, e.g. the PrIME project of the SEI [10], the ARMONÍAS project of the ALARCOS research group [11], or Enterprise SPICE [12], among others. However, although it is possible to see an increase in the interest in proposals defined for this type of environment, few efforts have been focused on providing technological support through software tools. It is therefore necessary to provide tools and a specialized technical infrastructure with which to both support the harmonization of multiple models and strengthen this research domain. A software tool would undoubtedly facilitate the guidance, implementation and management of any harmonization project.

Bearing all this in mind, this paper describes a WEB tool, denominated as HProcessTOOL, which allows the realization of an organization's harmonization projects to be managed, controlled and monitored. HProcessTOOL is a wizard that guides the step-by-step harmonization of multiple models. More precisely, it allows us to: configure a harmonization strategy; choose a widespread harmonization strategy (WHS); mange generated knowledge and store the information from any model through the use of a common schema or Common Structure of Process Entities (CSPE), making the information collected from the models available for future work. This tool supports the Harmonization Process, which is part of a Harmonization Framework (HF) developed within the ARMONÍAS project. The HF integrates a set of techniques, methods, recommendations and concepts defined to support the harmonization of multiple models independently of the implementation approach of the models involved. A summary of both the Harmonization Process and the Harmonization Framework is presented in [13].

The paper is organized as follows. Section 2 presents an overview of the related works. Section 3 is divided into 3 parts: the first sets out an overview of the Harmonization Process, the second describes the Architecture of HProcessTOOL and the third sets out the modules of HProcessTOOL which have been developed. Section 4 presents a summary of the case studies in which the tool has been applied. Finally, our conclusions and future work are outlined in Section 5.

2 Related Work

Several software tools that offer control and planning in projects can be used as a basis for managing projects. Although these tools provide functions to support project management, they do not provide features focused on the harmonization of multi-models.

We are not aware of any other attempts to address the harmonization of multiple models through a tool. Therefore, and since the harmonization of multiple models is closely related to process improvement, we believe that it is important to analyse the differences between other tools developed to support software process improvement and our proposal. This will make it possible to verify whether the aforementioned tools can be used in these kinds of environments or whether a special type of tool, such as HProcessTOOL, is necessary. Table 1 shows a search of related works in which those

Table 1. Tools for process improvement and harmonization of multiple models

Type of environment focused on		MKS Integrity Suit	SIMPLe	QMIM Quality Organizer	HProcessTOOL
Type of tool	Desktop	X	--NA--	--NA--	--NA--
	Web	--NA--	X	X	X
Type of license	Free	X	--NA--	?	--NA--
	Commercial	--NA--	X	?	X
Knowledge base or Supported models		CMM [14], CMMI [15].	CMMI [15]	CMMI and other models such as ISO standards, ISO-IEC standards and 9 Hungarian standards.	Any. However, CMMI, ISO 20000, ISO 27001, ITIL V3, COBIT 4.1, RISK IT, BASEL II, VAL IT and ISO 27002 are currently stored.
Technique, method, process or model taken as guideline		?	IDEAL [1]	It supports the QMIM Framework (Quality through Managed Improvement and measurement)	Harmonization Process [13], ARMONÍAS Project [11]. Also supports the homogenization and comparison technique (see [9] and [16] respectively).
Does it support process improvement?		X	X	It only allows a CMMI-based assessment to be carried out.	It can be used as a support tool for process improvement when multiple models are involved.
Does it support the harmonization of two or more models?: multiple models.		--NA--	--NA--	?	X
Type of support		Monitoring, Control of changes (applications and documented process) and design of process.	Supports the documentation of organizational processes and an improvement project in general. It allows the generation of automatic creation of activities.	Quality organizer to improve the understanding and relationships between models, using QMIM Framework as a basis.	Provides a wide solution through which to manage, control and monitor harmonization projects with multiple models. This tool allows repetitive actions to be carried out and reduces the cognitive load of the individuals involved in a project of this type.
Reference		[17]	[18]	[19]	[20]

Some Conventions Used→ NA: Not Applicable, X: Applicable, ?: No information found.

tools that do not offer features oriented towards process improvement and the harmonizing of multiple models are excluded. The literature retrieved from this analysis has been classified into two categories: (i) tools that support the improvement process and (ii) tools that support the harmonization of multiple models. Other features such as: type of tool, type of license or supported models have also been analysed.

Upon considering the situation set out in Table 1, it is possible to observe that MKS Integrity Suit and SIMPLe are not independent of the reference models supported. They use related guidelines to support software process improvement. They do not, therefore, use a technique, method, process or methodology to support the harmonization of multiple models. The aim of QMIM Quality Organizer is to facilitate the understanding and selection of the best model and/or standard from an assessment of the current situation in Hungarian software companies. Although it contains information about the most popular quality approaches, standards and models, it does not define methods, techniques or tools to support the comparison, integration or unification of multiple models. Moreover, it is only focused on the software domain.

In contrast to existing tools, HProcessTOOL offers support which allows the harmonization of multiple models to be managed independently of the reference model to be harmonized. It can also be used as a support tool to address software process improvement when multiple models are involved, and additionally permits the harmonization of models with regard to software.

3 HProcessTOOL: WEB Tool for Supporting Harmonization Projects

HProcessTOOL is a WEB tool that provides a solution with which to manage, control and monitor harmonization projects. This tool allows repetitive actions to be carried out and reduces the cognitive load of the individuals involved in a project in which multiple reference models are necessary. HProcessTOOL uses the Harmonization Process defined in the HF as a basis (section 2.1). The Harmonization Process is employed to guide a work team through any harmonization project in which it is necessary to harmonize multiple models. It also supports other elements defined in the Harmonization Framework such as providing the person responsible with a step-by-step wizard guide to the configuration of a harmonization strategy during the execution, (see 2.1). HProcessTOOL is also a flexible environment, since it is independent of the reference models to be harmonized, and therefore harmonizes the structure of the models involved through the use of the Common Structure of Process Entities (CSPE) defined in [9]. This signifies that all the models chosen by an organization will be harmonized at the level of their process entity, which simplifies the implementation of other techniques, such as comparison and integration.

A brief summary of the harmonization process that HProcessTOOL uses, HProcessTOOL's Architecture and its characteristics, is presented in the following sections.

3.1 The Harmonization Process

The main objective of the harmonization process (Figure 1) is to establish the harmonization strategy, which describes the techniques and activities that must be

performed in order to harmonize multiple models [13]. The Harmonization Process consists of four main activities: (i) Starting, (ii) Analysis and Definition, (iii) Execution and (iv) Revision, depending on the harmonization strategy selected. The Harmonization Process allows one or more harmonization iterations to be configured in the execution activity. An iterative and incremental approach makes it easier to manage the complexity related to the harmonization strategy to be executed in this activity.

The process additionally describes a set of roles: Performer (P), Process Engineer (PE), person Responsible for Managing the Process of Harmonization (RMPH) and Steering Group (SG). It also describes five main work products: Analysis of Needs and Identification of Cases Prior to Harmonization (PT01_A2_ANICPH), Harmonization Strategy (PT01_A2_HS), Implementation Report of the Harmonization Strategy (PT02_A2_IRHS) and Knowledge Base (PT02_2_KBHC). A more detailed description of the Harmonization Process edited with the EPF Composer is presented in [11], and a detailed summary of its elements can be seen in [13].

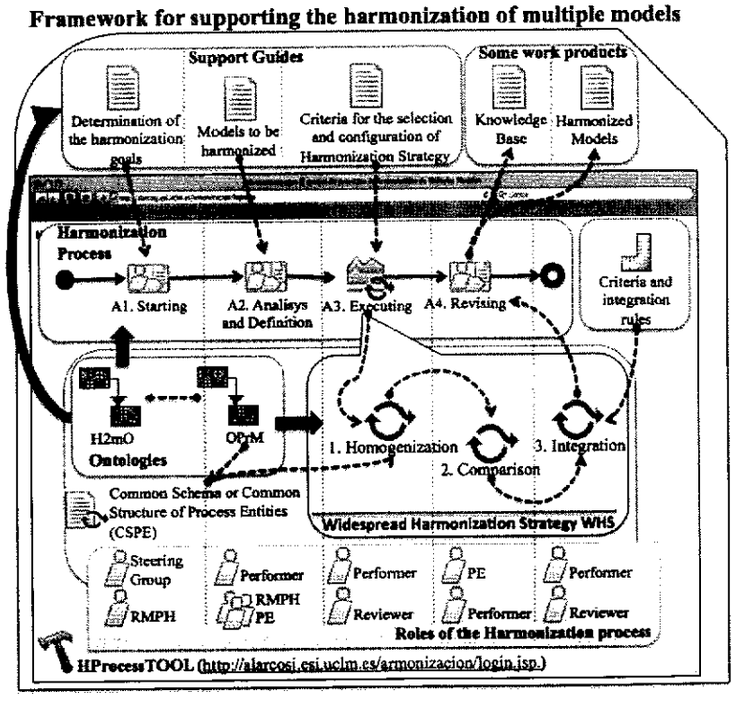

Fig. 1. Framework for supporting the harmonization of multiple models (taken from [21])

3.2 Architecture and Technological Considerations

HProcessTOOL is a flexible and scalable system which uses a client-server architecture that is applied by means of three layers, as follows:

- The *interface layer* (see left-hand side of Figure 2), also known as the presentation layer or application, contains the information and logic needed to submit requests and receive answers from the client. Its main components are the servlets and JavaServer Pages (JSP). Since our aim was to display rich analysis charts of a professional quality, we decided to use JFreeChart plug-in [22].
- The *control layer* (see right-hand side of Figure 2) contains the components (set of classes) of which the behavior and logic functionality core of HProcessTOOL is formed. This was developed by using Java JEE.
- The *data layer* (see right-hand side of Figure 2) is responsible for the persistence of the information generated by the Web tool. It is made up of a MySQL database.

Figure 2 shows a summary of the three layers of which HProcessTOOL is formed.

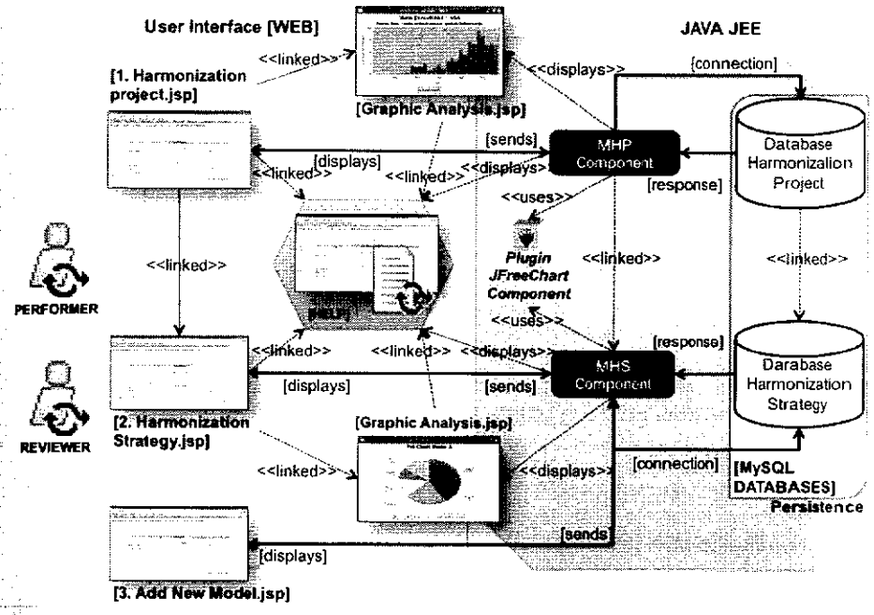

Fig. 2. General Architecture of HProcessTOOL

As regards the kind of users supported by the tool, HProcessTOOL supports two roles: the *Performer* which is based directly on the *Performer (P)* role defined in the Harmonization Process and the *Reviewer*, which is an adaption of the *Reviewer (R)* role defined in the mapping technique presented in [16].

The P is the person who is responsible for managing the harmonization project, analysing models and implementing the harmonization techniques. The review of the tasks and work performed by the P is carried out by the R, who verifies the reliability of the results obtained in both the harmonization process and the harmonization

strategy. Both the P and R therefore have access to all the modules developed in HProcessTOOL.

3.3 Modules of HProcessTOOL

HProcessTOOL supports five main functionalities, as is shown in the general use case diagram in Figure 3.

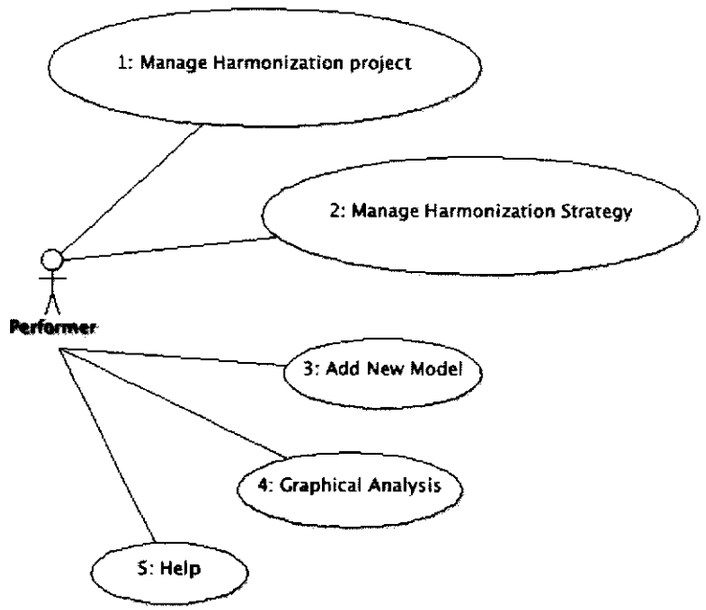

Fig. 3. Use case diagram of HProcessTOOL

As can be observed in Figure 3, the main functionalities supported are:

(1). *Management of the Harmonization Project (MHP).* This module allows a multiple model harmonization project to be managed, controlled and monitored. Tool's basis consists of the activities, tasks, steps, work products and certain roles such as the P role defined in the Harmonization Process (see Figure 1). The management carried out through this module is focused on four variables, which are:

- The control activity.
- Effort (estimated, actually made and number of people involved).
- The control date (starting and finishing date).
- Documents associated with the performance of each activity.

The control of the activities performed is carried out by using a check box which allows completed activities to be controlled. We have considered it important to add a field to store the additional information as part of the generation and management of a

Knowledge Base (KB). The KB can store issues such as: problems, positive aspects, negative aspects, solutions, notes, and so forth. The KB option is present in each activity, task and role. In general, the MHP uses a database, which allows all the information related to this module to be stored. Figure 6 shows an example of the management of a harmonization project.

(2). *Management of the Harmonization Strategy (MHS).* This module, which is also called MHS, allows the definition and systematic configuration of a harmonization strategy to be carried out. The MHS is divided into two options or sub-modules: either the configuration of a New Harmonization Strategy (NHS) or a Widespread Harmonization Strategy (WHS). These are described as follows:

- The NHS can be configured from a set of methods and/or techniques used by the organization. The tool has a specific module with which to create the activities, tasks and roles used to describe the process that is necessary.
- The WHS is a set of three stages or techniques:

  i). *Homogenization*, which provides the most suitable tools to harmonize the models involved through the addition of their information by means of a Common Schema or Common Structure of Process Entities (CSPE).

  ii). *Comparison*, which allows the identification of differences and similarities between a set of models to be carried out.

  iii). *Integration*, which provides the support needed to combine and/or unify the best practices of different models. A detailed summary of these techniques can be found in [9] and [16] respectively. The tool currently supports the homogenization and comparison technique. However, the integration technique is being developed from the results obtained from a case study whose main objective was the integration of a set of models to support the procedures and activities related to Information Technology (IT) Government in banking. A detailed analysis of the management of this is presented in Section 4, along with another case study.

Both NHS and WHS depend on a harmonization project having been created and opened. Figure 4 shows an example of the comparison between ISO 20000 and ISO/IEC 27001, which is performed through the harmonization strategy defined for Case Study 1 (explained in Section 4).

(3). *Add a new model.* This module allows the information in a new model to be added through a homogenization technique used by the WHS and the CSPE structure. However, unlike the MHS component, it does not depend on a project having been created and opened. Figure 5 shows Clause 4.2 of ISO 27001 which was added through the CSPE.

(4). *Graphical Analysis.* This module allows the data stored in MHP and MHS to be deployed through a graphical analysis by means of the JFreechart plug-in [22]. Some of the graphical analyses that can be carried out with the tool are: Gantt diagrams, activity, task and role diagrams in which, amongst other things, the time and effort that were estimated and were actually taken/made are analyzed.

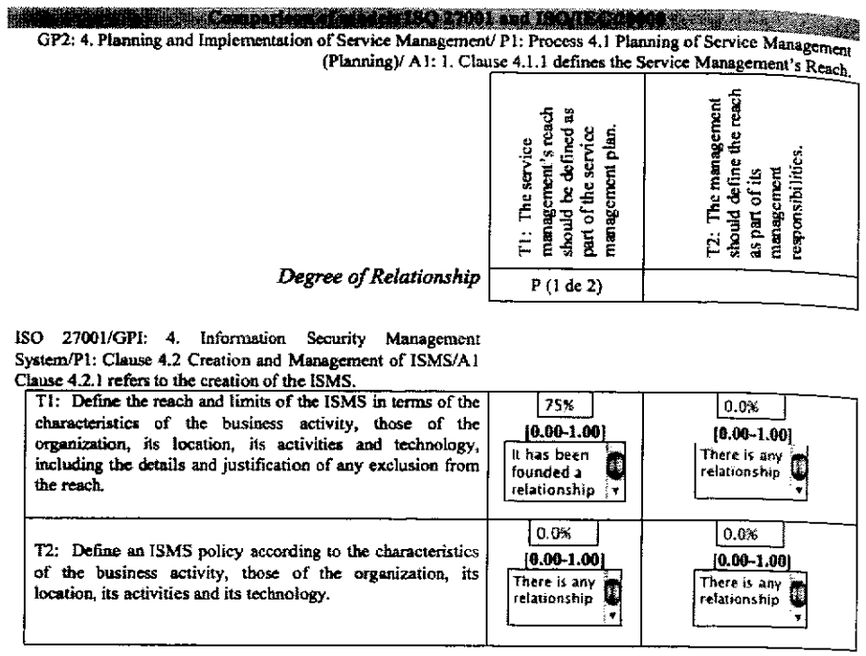

Fig. 4. Comparison between ISO 20000 and ISO/IEC 27001

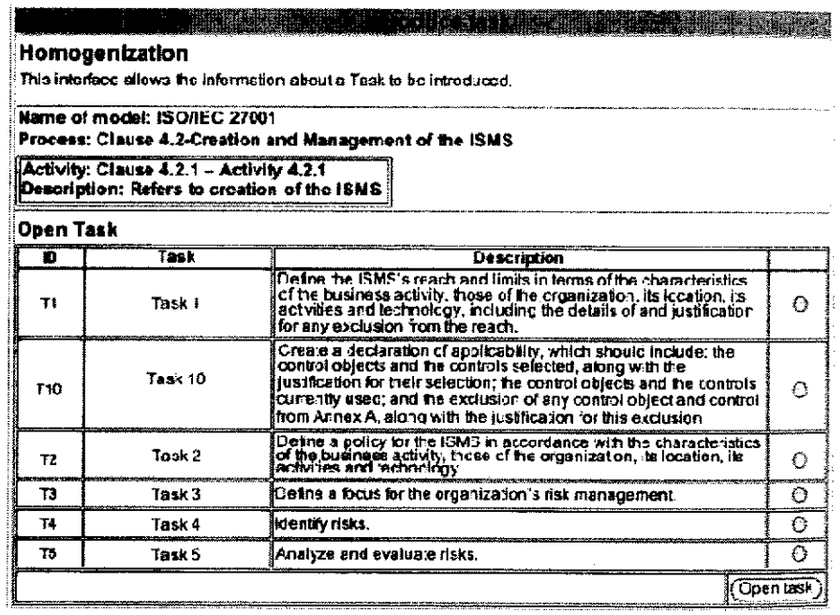

Fig. 5. Clause 4.2 of ISO 27001 stored through CSPE

(5). *Help*. This module offers two sorts of aids. The first offers a step-by-step guide to the harmonization process, which can be seen in the WEB in [11], and the second is a step-by-step guide as to how to use each of the functionalities of HProcessTOOL. The latter can only be obtained through the WEB tool.

4 Applications of the Tool

The tool presented in this paper has been successfully used in the management of two different harmonization projects or case studies. These are described as follows:

1. The first harmonization project was focused on supporting the management of the harmonization of ISO 27001 and ISO 20000 part 2 as a requirement of a consultancy company called Audisec, which offers consultancy in these standards. The main objectives were to identify the differences and similarities between these standards, the level to which they are complementary, and to resolve the discrepancies between them, thus facilitating the certification of organizations in the ISO 20000 standard by considering the efforts made in previous certifications obtained for ISO 27001.
2. The second harmonization project was a research project, which sought the unification of a set of models to support different needs in Information Technology Governance when applicable to the Superintendence of Banks in Guatemala, and the banking sector in general. The model obtained integrates some of the processes of COBIT 4.1, VAL IT, RISK IT, ISO 27002 and ITIL V3, and the principles of Basel II, all of which go under the name of ITGSM. The integration process has initially been performed for the definition of 22 of the 44 processes proposed by ITGSM. A detailed summary of the ITGSM model is presented in [23].

A detailed summary of the management of both case studies is presented in [13] and [24] respectively. The management, control and monitoring were all performed by using HProcessTOOL. This allowed a suitable management of the work products, effort, time, roles involved and knowledge generated to be performed. It also allowed an appropriate and broad analysis of the projects to be made through the use of charts concerning the data stored from each project, Figure 6 shows an example of the management of the ITGSM harmonization project (we maintain the original screen shot, which is in Spanish).

The HProcessTOOL, through MHS, also allowed the configuration of a harmonization strategy according to the needs of each case, e.g. in the first case the MHS component allowed the techniques supported by the WHS component to be used, that is, it only included the homogenization and comparison techniques. However, since in the second case it was necessary to unifying multiple models, the tool did not support the integration of the models. This was therefore documented by using a word processor.

From the results obtained and the feedback received it is possible to state that companies that have not used HProcessTOOL could benefit from the Knowledge Base generated with regard to the models' information and relationships established in the comparisons.

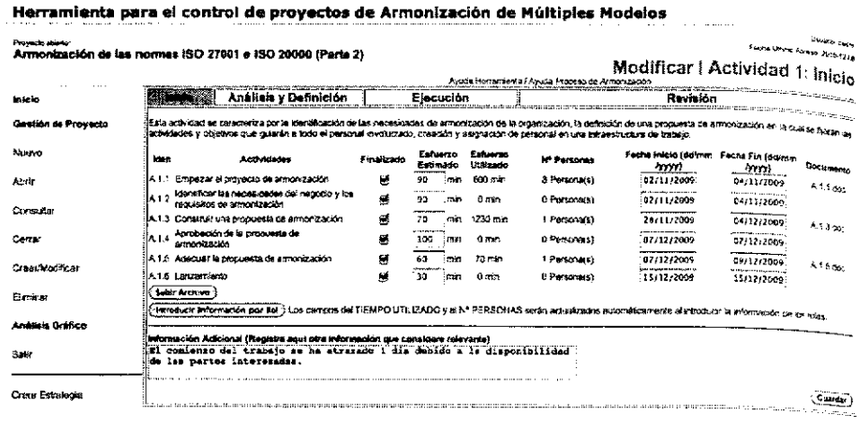

Fig. 6. Example of the management of the ITGSM harmonization project

5 Conclusions and Future Work

At present, and given the existence of different business and operative needs, enterprises are obliged to use more than one reference model at the same time. This kind of environment requires more time, effort and associated costs than the conventional environments for software process improvement, which are characterized by their use of only one model. This signifies that the tools and methodologies defined to support SPI projects are not applicable to multi-model environments. It is therefore necessary to provide tools and a specialized technical infrastructure with which to support the harmonization of multiple models and to strengthen this research domain.

This paper has presented a Web tool to support the harmonization of multiple models. HProcessTOOL provides a suitable work environment, independent of the reference models to be harmonized. It also allows the time, effort and resources used in a harmonization project to be optimized. HProcessTOOL has additionally been developed to provide support for any type of company, i.e., micro, small, medium and large enterprises. However, given that small companies have a single combination of features, it is possible that they will benefit most from our tool. We do not wish to infer that HProcessTOOL supports all the problems related to the harmonization of multiple models. However, the main objective of HProcessTOOL is to support the principal needs identified according to our experience.

Two harmonization projects have been managed with the first version of HProcessTOOL. The results obtained have been successful since the tool has allowed the following to be carried out: the identification and resolution of discrepancies between ISO 27001 and ISO 20000 part 2; support to be provided for the homogenization and comparison of BASEL II, COBIT 4.1, VAL IT, RISK IT, ISO 27002 and ITIL V3.

Since the harmonization project of the ITGSM Model was initially performed for the definition of 22 of the 44 processes proposed, as future work we aim to track this case study and to discover whether the tool has also allowed the 22 remaining processes to be successfully managed. We additionally wish to discover whether the use of HProcessTOOL has implied a reduction in the effort and costs associated with the

implementation of harmonization projects without a software tool. In a similar vein, we also aim to include the module concerning the integration technique in the widespread harmonization technique and to improve the tool using the feedback received from new harmonization projects.

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