XVII

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Sistedes 2012

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Almería, 17 al 19 de Septiembre

Editores: Antonio Ruíz | Luis Iribarne

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JISBD 2012

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Prólogo

Las XVII Jornadas de Ingeniería del Software y Bases de Datos (JISBD) (JISBD 2012) se celebraron del 17 al 19 de Septiembre de 2012 en Almería y fueron organizadas por Grupo de Investigación de Informática Aplicada de la Universidad de Almería. Al igual que en anteriores ediciones, JISBD se celebró en paralelo y compartiendo algunos actos de las XII Jornadas de Programación y Lenguajes (PROLE) y de las VIII Jornadas de Ciencia e Ingeniería de Servicios (JCIS). Lo tres eventos son organizados bajo el auspicio de SISTEDES, la Sociedad de Ingeniería del Software y Tecnologías de Desarrollo de Software.

JISBD se ha consolidado como un foro de referencia donde investigadores y profesionales de España, Portugal e Iberoamérica, en los campos de la Ingeniería del Software y de las Bases de Datos, pueden debatir e intercambiar ideas, crear sinergias y, sobre todo, conocer la investigación que se está llevando a cabo en dicha comunidad. A fin de conseguir de manera efectiva este espacio de intercambio, las jornadas se organizaron por sesiones temáticas en las que han tenido cabida hasta cinco tipos de contribuciones: (1) trabajos regulares, que presentan algún resultado de investigación, (2) trabajos emergentes, que están comenzando su andadura, (3) demostraciones de herramientas, (4) trabajos relevantes ya publicados y (5) tutoriales. Para iniciar el debate indicando los aspectos más destacables y los más discutibles de cada contribución, los coordinadores de sesión delegaron parcialmente dicha responsabilidad en la figura del contraponente de cada contribución.

Las sesiones temáticas de esta edición han sido:

- *Sesión 1:* Bases de Datos, Almacenes de Datos, Minería de Datos, Recuperación de la información
- *Sesión 2:* Ingeniería Web, Interfaces de Usuario, Sistemas Colaborativos, Computación Ubicua
- Sesión 3: Apoyo a la decisión en Ingeniería del Software, Metodologías, Experimentación
- *Sesión 4:* Calidad, Pruebas y Requisitos
- *Sesión 5:* Desarrollo de Software Dirigido por Modelos
- *Sesión 6:* Líneas de Producto, Componentes y Arquitecturas Software
- *Sesión 7:* Otros aspectos de Ingeniería del Software y Bases de Datos.

Este volumen presenta las 86 contribuciones que han formado parte de esta edición: 35 trabajos regulares (con un 71% de ratio de aceptación), 19 trabajos emergentes (con un 89% de ratio de aceptación), 18 trabajos ya publicados, 14 herramientas y 2 tutoriales. También ofrece una breve reseña de la charla invitada impartida por el profesor Armando Fox de la Universidad de California, Berkeley titulada: "Cruzando el abismo educativo" de la ingeniería de software utilizando Software como Servicio y computación en nube. Agradezco que aceptara formar parte de estas Jornadas y su más que colaborativa disposición.

Un signo que acompaña la madurez de la comunidad es la existencia de un abanico de herramientas software cada vez más poblado y de mayor calidad. En esta edición se dispuso un comité de apoyo para su revisión y se organizó una breve sesión plenaria el último día donde dar a conocer y discutir sobre el "mapa de herramientas" de la comunidad JISBD. Estamos convencidos de que esta iniciativa aumentará las sinergias entre los grupos de investigación y por ende aumentará el valor del conocimiento científico y tecnológico que va atesorando nuestra comunidad.

Me gustaría expresar mi más sincero agradecimiento a los miembros del Comité de Programa por su tiempo y dedicación a la hora de revisar y seleccionar los artículos que fueron finalmente aceptados para su presentación, y que han permitido confeccionar un año más un programa de gran calidad y nivel. También a los distintos Coordinadores que se han ocupado de organizar aspectos esenciales como las demostraciones de herramientas (Cristina Vicente y Fernando Sánchez), trabajos relevantes (Amador Durán), tutoriales (Ángeles Saavedra) y coordinadores de las diferentes sesiones temáticas. Por supuesto, mi agradecimiento a los autores que enviaron artículos a las Jornadas, hayan sido aceptados o no, por su esfuerzo y contribución al evento.

También me gustaría agradecer al equipo del comité de organización liderado por Luis Iribarne su gran esfuerzo y excelente trabajo, que han permitido hacer realidad esta conferencia; al Comité Permanente de las JISBD por depositar su confianza a la hora de presidir el Comité de Programa, y por su constante apoyo y soporte. Mención especial merece Coral Calero, cuyos consejos y ayuda como presidente saliente han sido siempre inestimables. Un especial agradecimiento a la Universidad de Almería, que ha hecho posible que la conferencia fuera todo un éxito. Asimismo, este evento no hubiera sido posible sin el aval de la Sociedad de Ingeniería del Software y Tecnologías de Desarrollo de Software (SISTEDES) y sin la colaboración de la Asociación de Técnicos de Informática (ATI), y la oficina española del W3C.

Muchas gracias a todos los asistentes y participantes a las JISBD 2012, y esperamos verles de nuevo en las próximas JISBD.

Almería, Septiembre 2012

Antonio Ruiz-Cortés
Presidente del Comité de Programa de JISBD 2012

Prologo de la Organización

Las jornadas SISTEDES 2012 son un evento científico-técnico nacional de ingeniería y tecnologías del software que se celebra este año en la Universidad de Almería durante los días 17, 18 y 19 de Septiembre de 2012, organizado por el Grupo de Investigación de Informática Aplicada (TIC-211). Las Jornadas SISTEDES 2012 están compuestas por las XVII Jornadas de Ingeniería del Software y de Bases de Datos (JISBD'2012), las XII Jornadas sobre Programación y Lenguajes (PROLE'2012), y la VIII Jornadas de Ciencia e Ingeniería de Servicios (JCIS'2012). Durante tres días, la Universidad de Almería alberga una de las reuniones científico-técnicas de informática más importantes de España, donde se exponen los trabajos de investigación más relevantes del panorama nacional en ingeniería y tecnología del software. Estos trabajos están auspiciados por importantes proyectos de investigación de Ciencia y Tecnología financiados por el Gobierno de España y Gobiernos Regionales, y por proyectos internacionales y proyectos I+D+i privados. Estos encuentros propician el intercambio de ideas entre investigadores procedentes de la universidad y de la empresa, permitiendo la difusión de las investigaciones más recientes en ingeniería y tecnología del software. Como en ediciones anteriores, estas jornadas están auspiciadas por la Asociación de Ingeniería del Software y Tecnologías de Desarrollo de Software (SISTEDES).

Agradecemos a nuestras entidades colaboradoras, Ministerio de Economía y Competitividad (MINECO), Junta de Andalucía, Diputación Provincial de Almería, Ayuntamiento de Almería, Vicerrectorado de Investigación, Vicerrectorado de Tecnologías de la Información (VTIC), Enseñanza Virtual (EVA), Escuela Superior de Ingeniería (ESI/EPS), Almerimatik, ICESA, Parque Científico-Tecnológico de Almería (PITA), IEEE España, Colegio de Ingenieros Informática de Andalucía, Fundación Mediterránea, y a la Universidad de Almería por el soporte facilitado. Asimismo a D. Félix Faura, Director de la Agencia Nacional de Evaluación y Prospectiva (ANEP) de la Secretaría de Estado de I+D+i, Ministerio de Economía y Competitividad, a D. Juan José Moreno, Catedrático de la Universidad Politécnica de Madrid, presidente de la Sociedad de Ingeniería y Tecnologías del Software (SISTEDES), a D. Francisco Ruiz, Catedrático de la Universidad de Castilla-La Mancha, y a D. Miguel Toro, Catedrático de la Universidad de Sevilla, por su participación en la mesa redonda "*La investigación científica informática en España y el año Turing*"; a Armando Fox de la Universidad de Berkley (EEUU) y a Maribel Fernández del King's College London (Reino Unido), como conferenciantes principales de las jornadas, y a los presidentes de las tres jornadas por facilitar la confección de un programa de *Actividades Turing*. Especial agradecimiento a los voluntarios de las jornadas SISTEDES 2012, estudiantes del Grado de Ingeniería Informática y del Postgrado de Doctorado de Informática de la Universidad de Almería, y a todo el equipo del Comité de Organización que han hecho posible con su trabajo la celebración de una nueva edición de las jornadas JISBD'2012, PROLE'2012 y JCIS'2012 (jornadas SISTEDES 2012) en la Universidad de Almería.

Luis Iribarne
Presidente del Comité de Organización
@sistedes2012{JISBD;PROLE;JCIS}

PrMO: An Ontology of Process-reference Models

César Pardo[1,2], Félix García[2], Francisco J. Pino[1,2], Mario Piattini[2] and María Teresa Baldassarre[2]

[1] IDIS Research Group
Electronic and Telecommunications Engineering Faculty
University of Cauca, Street 5 # 4 - 70.
Kybele Consulting Colombia (Spinoff)
Popayán, Cauca, Colombia.
{cpardo, fjpino}@unicauca.edu.co

[2] ALARCOS Research Group
ITSI, Information Systems and Technologies Department
University of Castilla–La Mancha, Paseo de la Universidad 4, Ciudad Real, Spain
{Felix.Garcia, 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

Resumen. For a couple of decades, process quality has been considered as one of main factors in the delivery of high quality products. Multiple models and standards have emerged as a solution to this issue, but the harmonization of several models in a company for the fulfillment of its quality requirements is no easy task. The difficulty lies in the lack of specific guidelines and in there not being any homogeneous representation which makes this labor less intense. To address that situation, this paper presents an Ontology of Process-reference Models, called PrMO. It defines a Common Structure of Process Elements (CSPE) as a means to support the harmonization of structural differences of multiple reference models, through homogenization of their process structures. PrMO has been validated through instantiation of the information contained in different models, such as CMMI-(ACQ, DEV), ISO (9001, 27001, 27002, 20000-2), ITIL, Cobit, Risk IT, Val IT, BASEL II, amongst others. Both the common structure and the homogenization method are presented, along with an application example. A WEB tool to support the homogenization of models is also described, along with other uses which illustrate the advantages of PrMO. The proposed ontology could be extremely useful for organizations and other consultants that plan to carry out the harmonization of multiple models.

Keywords: Harmonization of multiple models and standards; homogenization; mapping; integration; ontology, processes.

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1 Introduction

Aiming to provide solutions that allow us to define suitable processes for addressing different needs, a wide range of models and standards have been developed (hereafter called *reference models*), which can be used as process reference models; e.g. ISO/IEC 20000-2, ISO/IEC 27001, ISO/IEC 9001, ITIL, SWEBOK, Cobit, ISO/IEC 12207, CMMI, and so forth. Besides these models, there are different assessment models, such as SCAMPI, ISO/IEC 15504-5, CBA-IPI, EIA/IS 731.2 Appraisal Method, SCE V3.0 Method Description, amongst others.

This mass of models and standards that has emerged means that software organizations can assess and institutionalize new or improved process, becoming more competitive and producing high quality products. They can likewise choose a particular model to cover a specific issue, or select several models to address different needs. Currently, there are different factors that may persuade an organization to consider the need to work with more than one model [1], e.g. (i) market niches with specific models, (ii) improvement of practices from legacy process models, (iii) business positioning, (iv) leveraged or merger corporate (v) systematic search of the capability of the processes, (vi) business growth, among others.

Software organizations have found it difficult to work with more than one model at the same time, however, and they often make a great effort to interpret them, due to the fact that each has been defined from different opinions, work groups, (cultural and political), interests and bodies. Each model therefore uses its own view on quality. That is, each of them defines its own process element structure, scope, orientation, purpose, and other characteristics. This has brought about some problems in the use of the reference models e.g. formal description of process models, compatibility and transformability, and benchmark of process attributes [2].

Bearing all the above in mind, our work has the objective and scope of giving a solution to the problem we have set out, defining an ontology which would be useful for harmonizing the process elements which have been described by different models. Our ontology identifies and makes use of the process elements which it would be made up of and that are also common to any reference model. It can thus be used independently of the reference model to be harmonized. Using the ontology, a common schema or *Common Structure of Process Elements* (CSPE) has been defined. This has allowed the homogenization of the process elements of some models, resolving their differences before carrying out any comparison, mapping, integration or unification. A prototype of tool which makes use of the models' information, homogenized through CSPE, is also shown.

This paper is organized as follows. After this introduction, Section 2 presents an analysis of the related works. Then Section 3 introduces PrMO, the Ontology of Process-reference Models. Section 4 shows the use of the PrMO, as well as a *Common Structure of Process Elements* to support the homogenization of multiple models and a homogenization method to support their application. Section 5 sets out the application of the common structure and homogenization of some process elements of ISO 20000-2, together with an overview of a supporting tool. Finally, conclusions and future work are presented in Section 6.

2 Background

In our search in the literature presented in [1], we have identified a few efforts related to harmonization of multiple models, such as PrIME project of the SEI [3], Enterprise SPICE [4], IT Governance Institute (ITGI) and Office of Government Commerce (OGC) carry out the alignment of Cobit 4.1, ITIL V3 and ISO/IEC 27002 for Business Benefit [5], among other publications and works analyzed. Few of them, however, have proposed solutions to resolve the problems and structural differences arising between models that are being harmonized. Most of them carry out the mappings in a unilateral direction and thereby the process structure of basis model is used as a main structure, e.g. the well known mappings of ISO to CMMI performed by Paulk [6], and Mutafelija & Stromber [7]. However, this solution is good only if the objective is focused from the beginning on the instantiation of the good practices of the base model; this is a situation that is impossible to replicate when the needs of the organizations are different. This point, therefore, makes us aware that the integration of models should be treated differently if we need to harmonize other models, e.g. ITIL and Cobit, or BASEL II and Val IT in the case of banking models, and so on.

Some studies have focused mainly on the development of ontologies to represent the key elements of particular domains; e.g. ontologies for representing the ISO and CMMI models, e.g. CMMI-SW [8], CMMI and ISO/IEC 15504 [9, 10], ISO 9001 and CMMI-SW [11]. Malzahn [12] defines an ontology to link the similarities between several models. Mendes & Abran present the engineering domain ontology developed taking SWEBOK as the basis [13], among others. These ontologies have been defined mainly aiming to understand the structure of the process-based quality approaches. We should add that we have also found other studies focusing on development ontologies for supporting business process integration, but this is a subject that is beyond the scope of this article.

Taking into account the situation set out above, we found most studies have focused mainly on the development of ontologies to represent and/or support the key elements of particular domains. This being so, we did not find any proposal standard that was independent and designed exclusively to support the homogenization of structural differences between multiple reference models before they are compared and/or integrated. Likewise, in contrast to related works analyzed, our proposal intends to provide a more fine-grained level.

3 PrMO: An Ontology of Process-Reference Models

PrMO is a subontology which extends one concept of H2mO [14], *quality model*. H2mO provides a formal and clear definition of the most widely-used techniques, methods and related terms in the harmonization of multiple models. PrMO complements H2mO, by means of establishing and clarifying the key process elements to support the harmonization of multiple models through homogenization of their process structures. In this section, we present an overview of the process architecture ontology designed. We then give a general overview of this and its instantiation from information contained in different models, such as CMMI-ACQ V1.2, ISO 9001, amongst others. We also provide the definition of a Common Structure of Process Elements (CSPE) and its application in the homogenization of *Specific Goal* (SG) 1 of Agreement Management of CMMI-ACQ. An example of instance of CMMI based on ontology is also shown.

3.1 Concepts of PrMO

The generic process constructors of PrMO have been designed by taking some process elements defined in the process structure of SPEM 2.0 [15], e.g. task and product. Using these standard elements and not others, e.g. process elements of a particular model such as CMMI, ITIL, etc., a homogeneous deal is ensured, which is independent of the process structure of reference models used during their harmonization.

Along with process elements taken from SPEM 2.0, we noted from our experience that it was necessary to add other process elements to give support to the homogenization of the process elements of other models with a higher degree of granularity or level of abstraction. Some examples we could point to and which are not described in detail in SPEM are the process elements of resource, tool and process category. The process elements added were identified from an analysis of a literature review of the commonly-identified process elements which are most widely modeled, presented in [16-23]. This allows us to specify some already-existing process elements more clearly and decompose them better.

Other auxiliary elements have been added too, such as associate elements or decomposed elements from other elements; for example- steps of tasks, in-out artifacts, human resources, time, and so on. Decomposition of elements allows support of the homogenization of process elements of models with a higher degree of detail, e.g. MoProSoft, Cobit 4.1, amongst others. We should add that, given that some concepts have already been defined by other studies, we have taken some concepts such as *Quality Model* and *Measure* of other (sub)ontologies; these are *Software Measure Ontology* and *Measurement Ontology*, which are part of Software Measurement Ontology (SMO) presented in [24]. These sub-ontologies establish and clarify the key elements in the definition of software measures, as well as the terminology related to the act of measuring software.

Taking into account the Representation Formalism for Software Engineering Ontologies known as REFSENO [25], it was possible to establish a basic cluster of *concepts (classes)*, *terminal concept attributes (attributes)* and *nonterminal concept attributes (relationships)* for representing any reference model. We used Protégé-OWL [26] as the tool for the creation of our ontology. Table 1 shows the glossary of the concepts of PrMO, according to REFSENO formalism; due to limits on space we have omitted the description of the terminal and nonterminal concept attributes. In an effort to support the homogenization of different models and the software engineering, some descriptions have been adjusted. A graphical representation of PrMO, both concepts and relationships, is shown in Figure 1, using the UML (Unified Modeling Language).

Table 1. Glossary of concepts in the PrMO.

Concept	Super-concept	Descriptions
Process Category	Concept	A *Process Category* is comprised of interrelated processes. [*New concept*].
Process	Concept	Coherent set of policies, organizational structures, technologies, procedures, purposes, objectives and work products that are needed to design, develop, deploy and maintain a software product. [*Adapted from* [18]].
Activity	Concept	This comprises a set of tasks or actions used to produce and maintain devices and achieve the objectives of the process. The activity includes the procedures, standards, policies and objectives to create and modify a set of work products. [*Adapted from* [16]].
Task	Concept	It is a process element that defines the work done by roles. A task is associated with the input and output products [*Adapted from* [15]].
Product	Concept	The set of artifacts to be developed, delivered and maintained in a project is called the product. The products can be input or output, whether mandatory or optional. Products are in most cases tangible artifacts consumed, produced, or modified by Tasks. [*Adapted from* [29] [15]]
Role	Resource	Describes a set or group of responsibilities, duties and skills required to perform a specific activity. [Adapted from [30]].
Resource	Concept	A resource is an asset that a business needs to have. In the field of software engineering, there are two main resources of importance: the developers and the tools. [Adapted from [17]].
Tool	Resource	The tools automate the execution of certain activities. [Adapted from [16]].

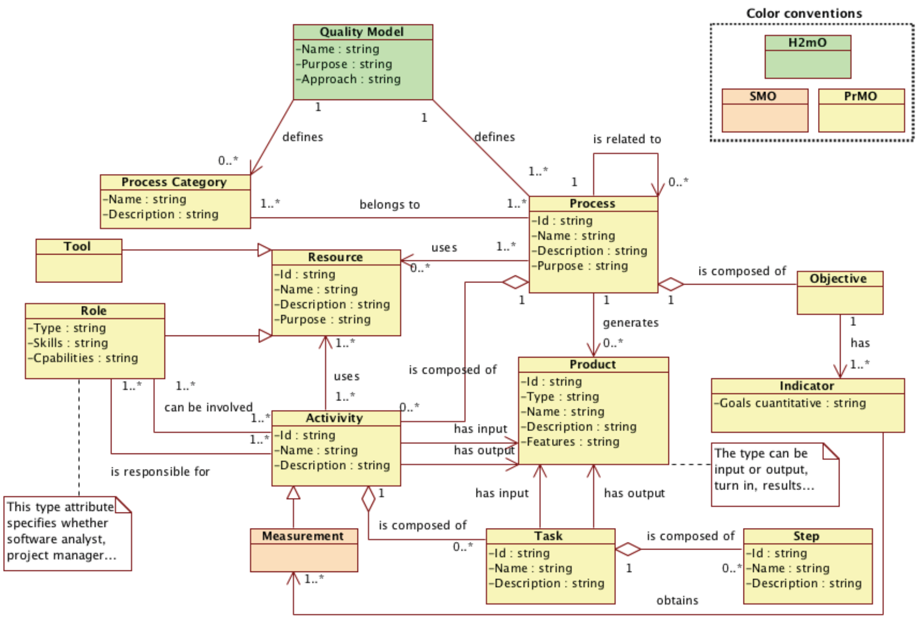

Fig. 1. Representation of PrMO.

As is shown in Figure 1, in general, the hierarchies between concepts represent the fact that in every model all processes in different categories or process groups are grouped together. In the same way, each process is formed by a set of elements or characteristics, such as: activities, tasks, roles, products or artifacts, measurements, and so on. We do not aim to take in characteristics of all models and existing standards, but rather those that are the most common, as well as those defined in the models analyzed, making its future adaptation and extension possible.

3.2 Instances of PrMO

Currently, the ontology has been applied and used with success in two real cases of application in the context of: (i) a research project in the definition of a unified model for banking sector and a consultancy organization to support the certification of ISO 20000 part 2 (ISO 20000-2) from efforts and institutionalized practices in ISO 27001 certificated companies. Based on PrMO, it was possible to homogenize and build some instances from it and to support the information contained in BASEL II, VAL IT, COBIT, RISK IT, ISO 27002 and ITIL for the first case and ISO 27001 and ISO 20000-2 for the second case. Due to the space limit, this section will focus on showing how the ontology has been instanced and used in two models: CMMI-ACQ and ISO 9001. Another factors such as: the harmonization strategy, homogenization, comparison and integration methods, benefits, findings and harmonization process followed to harmonize the models and standards involved in the case studies are presented in [27] and [28].

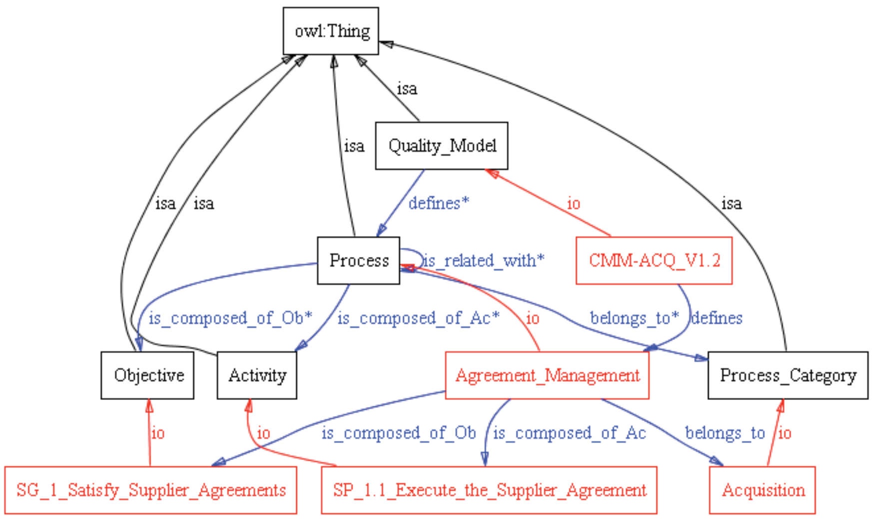

Fig. 2. Instance of CMMI-ACQ V1.2 using PrMO.

Figure 2 and 3 show excerpts of the instances of CMMI-ACQ V1.2 and ISO 9001:2008 using Prótegé-OWL. In Figure 2 it is possible to see that the *Agreement Management* (AM) is a process, which belongs to the *Acquisition Category* of CMMI-ACQ, and AM is composed of an *Objective* (*Specific Goal* (SG) 1 concerning *Satisfy Supplier Agreements*). It is also possible to see the *Specific Practices* (SP) related to this SG. Aiming to improve the understanding of the figure, we have eliminated some concepts, such as *task* and *products* and their nonterminal concept attributes. Figure 3 shows that *Clause 4 System Quality Management* has been considered as a process of ISO 9001:2000, which belongs to Process Category of the same name. We may also observe one of its activities, *Clause 4.2.3,* concerning control of documents relating to the list in the letters a, b, c, d, e, f, g, the control set needed to carry out this procedure (e.g. approve, review, update documents, and so on). *Clause 4.2.1,* concerning products which the documentation system of quality management should include, are mentioned in the letters a, b, c, d and e of this clause.

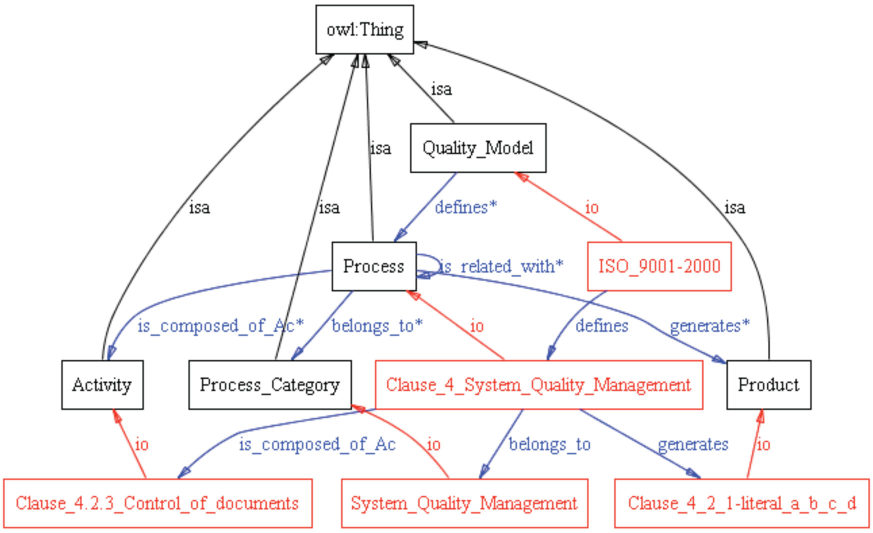

Fig. 3. Instance of CMMI-ACQ V1.2 using PrMO.

PrMO does not only support reference models with a clearly defined process structure but also the models whose elements are organized in less detailed structures. Therefore, PrMO can support other domains such as business where models' architectures may vary (not having such en emphasis on a process dimension) like software, security, amongst others. An example of homogenization of structures of several models by means of PrMO is presented in Table 4. Since each instance (of PrMO) was constructed in the same way, it was possible to map the models by means of similar process elements. CSPE thus allows us to resolve the differences between them and to prepare any reference model before carrying out any comparison, integration or activity concerning harmonization of multiple models.

4 PrMO as Basis to Homogenize Multiple Models

4.1 Common Structure of Process Elements (CSPE)

From process elements defined in PrMO, we have designed a Common Structure of Process Elements or CSPE template, which allows us to have a means of facilitating and supporting the harmonization of multiple models, through the homogenization of their process structures. CSPE is divided into four sections, which are described next:

- **Section 1: Description (SD1)**. Includes the: process category, process, objectives, activities and related tasks;
- **Section 2: Roles and Resources (SRR2)**. Includes the: resources, tools, roles and Work disciplines defined to carry out the process development, activities or tasks;
- **Section 3: Control (SC3)**. Relates the artifacts, deliverables, results, goals and measurements that serve as verification milestones in the execution of an activity or task;
- **Section 4: Additional Information (SAI4)**. Involves related processes and methods needed to obtain a purpose.

In next sections the HoMethod and its application are presented.

4.2 HoMehtod: A method for homogenization of models

To describe the process elements making use of the proposed structure, we suggest following a homogenization Method (HoMethod). The purpose is to guide the homogenization of multiple models step-by-step. In order to organize and manage the people, activities and steps defined in this method, we define two roles which support their execution: the performers and the reviewers. The activities and tasks, of which HoMethod is made up and which make use of the proposed structure, are presented below:

i). **Acquisition of knowledge about the models involved**. Before carrying out the execution of the harmonization of models, it is suggested that an analysis of each model be carried out, according to some of their elements and/or attributes, e.g. approach, size (number of pages), the development organization,

ii). **Structure analysis and terminology**. The analysis of the structure of a model can turn out to be one of the initial implicit steps in carrying out the implementation or improvement project. Homogenization supports an exhaustive analysis of terminology, syntax and identification of specific words for the models.

iii). **Identification of requirements**. Once the analysis has been done, it is possible to carry out the identification of requirements of software process to be homogenized. That allows us to identify which information of the model will be matched and organized in the structure elements. An example of syntax defined to identify the requirements in the ISO models family is presented in Table 2.

iv). **Carrying out the correspondence**: Such correspondence shows the models reorganized in the four sections of process elements described by CSPE structure. The object of homogenization is to prepare the models for harmonization in multi-model environments.

v). **Analyzing the results**: This activity involves the tasks: resolving the discrepancies of the outcomes of the performers (by reviewers) and verifying and validating these results (by reviewers).

vi). **Presenting the homogenized model**.

Table 2. Syntax to identify the requirements in ISO 20000-2.

Syntax	Descriptions
Shall [verb]	This statement indicates the actions, activities, tasks or procedures that the organization that will develop it will have. It is probable that this statement will be used to describe one or several actions or to derive processes.
Shall [verb] … and [verb]	
Begins with [shall] or shall [verb] that	Identifies a list of derived requirements of processes, procedures, activities or tasks.
Shall be [verb]	Indicates the characteristics associated with a process, or possible roles or work products.
Shall [include]	Indicates the details that the organization must include in a process or work product
Shall be [verb] + [by], [to] or [on]	This syntax helps to identify the detail of some procedures or processes.
Documented, input, output	Indicates a possible work product. It might includes some characteristics related to the work product.

5 Application of CSPE

In this section, we describe the steps carried out for the homogenization of models and requirements contained in ISO 20000-2. Table 3 shows an example of homogenization of clause 6.5 of ISO/IEC 20000-2 using the CSPE template and its application employing HoMethod.

5.1 Homogenization of ISO 20000-2

We will now give a brief summary of the application of the steps described, implementing the common structure in homogenization of the ISO 9001:2000 standard. The semantic analysis of the standard was carried out in the same way as other authors such as Paulk [6] and Mutafelija & Stromber [7] have done, where the requirements are identified by analysing the "Shall" and "Should" statements. Based on a syntax table to identify the requirements in ISO 9001 defined in [31], analysis and identification of both requirements ISO 9001 and ISO 20000-2 were carried out. This syntax analysis allowed us to identify the practices required by the standards better, thereby decreasing a large part of the ambiguity and subjectivity that is an integral part of trying to understand them. Table 2 shows the syntax used to identify the requirements in ISO 20000-2; it has been extended and updated from syntax defined in [31] which did not include the analysis of input or output statements and clauses as possible work products. These are described in all ISO standards.

An example of the result of the homogenization is shown in Table 3. On the table, clause 6.5, related to capacity management defined in ISO 20000-2, is organized and structured according to the CSPE Template. In this table we can see that not all the elements of the four sections of the common structure found any correspondence. This is because the standard "doesn't define" or set out detailed information for that correspondence.

Table 3. Homogenization of clause 6.5 defined in ISO 20000-2.

Process 6.5 Capacity management				
SD1.1. Process Category		6. Service Delivery Processes		
SD1.2 Processes	*ID:*	6.5	*Name:*	Capacity management
	Goal	To ensure that the organization has, at all times, sufficient capacity to meet the current and future agreed demands of the business.		
SD1.4. Activity	**SD1.5. Task**			**SC3.1. Artifacts**
The Clause 6.5 refers to the capacity management	1. The current and expected requirements of the business in relation to service should be known, in terms of what the business is going to need for it to be able to give a service to its clients. 2. The business forecasts and estimates of workload should be translated to specific requirements and must be documented. 3. The result of changes in workload or environment should be predictable. 4. Current and historical data of the use of components and resources should be collected and analyzed at the appropriate level to support the process. 5. Management capacity should be the focal point for all issues of performance and capacity. 6. The process should provide direct support to the development of new services and modifications to these, performing a sizing and modelling service. 7. A capacity plan must be generated and this should be prepared annually, at least. 8. A good understanding should exist of the technical infrastructure and its present and projected capabilities.			1. Capacity plan that documents the actual performance of the infrastructure and the expected requirements, often enough to take into account the rate of change of services and service volumes, information reports and change management in the client's business. 2. Documentation with the existing options, along with the cost involved in meeting the business requirements and solutions recommended for achieving the service level objectives.
SAI4.1 Related processes		Clause 6.5 is related to clauses 6.1, 7.2 y 9.2.		

ISO 20000-2 neither defines nor documents clearly many of the requirements that it suggests should be put into operation (for example activities, tasks and artifacts). Correspondence and formalization of the information presented in it with regard to process elements of structure had made it more possible to understand the requirements associated with it. An example is the identification and correspondence of activities, tasks and artifacts. For greater detail about the original descriptions of models analyzed, we suggest the corresponding reference be consulted.

The proposed structure has also been applied to other models and standards, such as CMMI (DEVelopment and ACQuisition), ISO 9001, Cobit 4.1, ITIL, Risk IT, Val IT, BASEL II, ISO 27001, ISO 27002, ISO 20000-2, PMBOK, and MoProSoft, see [27, 31, 32].

5.2 Homogenization through a supporting tool

Within the ontology groundwork, we designed and developed one of the functionalities of HProcessTOOL [33], which is a web tool to manage harmonization projects by supporting specific techniques. It also supports the management which controls and monitors the resulting harmonization projects. When a user logs on to HProcessTOOL, s/he can harmonize the models involved in a harmonization project through CSPE, which, as discussed earlier, is a template based on PrMO which takes some process elements defined in it and provides a way to support the harmonization of reference models.

Our tool has been used successfully in case studies presented earlier, see [33]. We have thus been able to validate and demonstrate that PrMO can be used on a WEB platform. We can also say that, given the generality of PrMO, it has not been necessary to use the mechanism of inheritance and restriction to homogenize multiple models. However, since each model uses different names to appoint its process elements or simply because some of them aren't defined, we have had to establish a correspondence table with regard to the process elements defined in the ontology. Currently, we have homogenized some models and standards through OPrM such as CMMI (DEVelopment and ACQuisition), ISO 9001,COBIT 4.1, ITIL, RISK IT, VAL IT, BASEL II, ISO 27001, ISO 27002, ISO 20000-2, PMBOK, and MoProSoft. Table 4 shows the table of correspondence used and an example to homogenize the process elements of some reference models such as CMMI (DEV and ACQ), ISO (9001, 27001, 20000-2) and COBIT.

Table 4. Correspondence of models according to OPrM.

PE of CSPE	**CMMI-DEV CMMI-ACQ CMMI-SVC**	**ISO 9001:2008 ISO 27001:2005 ISO 20000-2:20011**	**COBIT 4.1**
	Example: CMMI-ACQ V1.2	**Example: ISO 9001:2008**	
Process Category	*Categories,* e.g. Support, Engineering, Process and Project Management.	*Requirements*, e.g. System of Quality Management.	*Domains*, e.g. Plan and organize.
Process	*Process Areas*, e.g. Agreement Management from CMM-ACQ.	*Principal Clauses*, e.g. clause 4 concerning System of Quality Management.	*Process*, e.g. PO1 concerning define a strategic IT plan.
Objective	*Specific Goal (SG),* e.g. SG 1 Satisfy Supplier Agreements	*Inherent Information*	*Inherent Information*
Activity	*SpecificPractices,* e.g. Specific Practice 1.1 Execute the Supplier Agreement.	*Subclauses (II[b]),* e.g. clause 4.1 concerning the general requirements.	*Activities,* e.g. PO1.1 IT value Management.
Task	*SCiSP[a],* e.g. numeral 5 concerning Monitor risks involving the supplier.	*Information Not found*	*Information Not found*
Artifact or Product	*Information Not found*	*Clause 7.3.4,* e.g. Participants in such reviews shall include representatives of functions concerned with the design and development stage(s) being reviewed.	*Rol &Responsibility Chart (RACI),* e.g. Business Executive role as responsible for: linking business goals to IT goals.
Role	*Information Not found*	*Clause 6.3.* e.g. nfrastructure includes, as applicable, a) buildings, b) process equipment (both hardware and software), and, c) supporting services	*Information Not found*
Resource	*Information Not found*	*Information Not found*	*Information Not found*
Tool	*Typical Work Products and,* e.g. Integrated list of issues.	*Subclauses (II[b]),* e.g. Clause 4.2.1, describes the term "documented procedure" as referring to a procedure that must be supported by processes to establish it, document it, implement it and maintain it.	*Outputs,* e.g. Strategic IT plan which must be obtained in aPO1.1 activity.
Measure	*Information Not found*	*Information Not found*	*Metrics,* e.g. to measure degree of approval of the IT strategic/tactical plans on the part of business owners.

a. SCiSP: Subpractices Contained in Specific Practices, b. II: Inherent Information

Other applications of PrMO are as follows:

- The CSPE is being used to develop a functionality which means the user can (design, construct, apply and analyze) make appraisals from reference models stored in HProcessTOOL. As it will be supporting reference models stored through HProcessTOOL and CSPE, it will be flexible enough to support process appraisals in the context of global software development and adaptable to possible changes that may occur with such models. In that sense, it could be a useful tool, making quality assessment and improvement of the organizations' processes possible at a global level.
- CSPE has demonstrated that it could be useful as a way of supporting the assessment of structural differences and of finding out the level of detail of the reference models involved in a harmonization project. This allows us to identify an initial set of differences that has to be solved before carrying out a mapping process.

6 Conclusions and Future Work

In this paper, PrMO has been presented, this being an ontology of process-reference models designed to facilitate the harmonization of multiple models and standards. It has been illustrated how PrMO has been instanced in a clause of ISO 20000-2. Using the ontology, we have developed a functionality, which, through a Common Structure of Process Elements CSPE, makes it possible to support the homogenization of structural differences found between reference models. It is part of a web tool called HProcessTOOL. We should also add that we are currently developing an appraisal tool, which permits the design, construct, application and analysis of assessments of an organization to be performed from the homogenized models and stored in HProcessTOOL.

The homogenization of models is currently a manual task, so, as future work, the next step in this study will involve the automation of the homogenization stage through development of specific algorithms which let us extend the capability of our tools. It is not our intention to automatize all the tasks and activities involved. We do, however, wish to help users with an automatic step during mapping or correspondence of process elements to our CSPE.

It should also be said that, since PrMO has been used to instance different process and reference models, it has shown that it can also be used as a basis for supporting the design and building of an organization's processes. That being the case, we hope to develop a functionality to support the definition of organizations' processes through our ontology and tool. The information stored will be able to be used as a benchmark of processes for other organizations, as well as to help them during definition of their own processes.

Although PrMO has been applied in the homogenization of several models, in the quest to cover a wider range of needs, we hope to extend models and standards modeled through PrMO and stored in HProcessTOOL.

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