Model-Based Meta-Standardization

Modeling Enterprise Standards with OPM

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***Abstract*—To cope with current inconsistencies and incompleteness of technical documents, we propose a combined, model-based structured graphical and textual meta-standard approach for specification, verification and validation of complex systems in general and ISO enterprise standards in particular. This methodology, developed under the auspices of the ISO TC 184/SC 5 OPM Study Group, is presented along with MBASE—Model-Based Authoring of Specifications Environment, which is designed to support authors of technical specifications while creating and editing model-based technical documents.**

Keywords: component; Model-Based System Engineering, Object-Process Methodology, Enterprise Standards, Requirements, Technical Documents

I. INTRODUCTION

Standards in general and enterprise standards in particular are supposed to be a solid source of authority and must therefore be unambiguous, consistent, and accessible. However, standards are often criticized as difficult to use for a variety of reasons, including inter- and intra-standard consistency, low accessibility, poor traceability, and ambiguity. A primary source of these problems is the fact that standards are not model-based. Rather, they are authored using primarily free text, which is often accompanied by graphical annotations, figures or diagrams. Quite often, the figures do not match the text or conflict with other figures.

Object-Process Methodology (OPM) [1] offers a holistic approach, backed by a formal yet intuitive graphic and textual language, for modeling enterprise-related standards. These standards are intended for such stakeholders as enterprise architects and executives, system integrators, service providers, device suppliers, and designers and developers of applications. These professionals are concerned with architecting enterprises while holistically integrating enterprises. Integration within and across enterprises encompasses systems that include supply chains, customer relations, the projects they execute, the products they deliver, the services they get and provide, the assets they maintain, and any other related components and processes needed to facilitate automation and integration of their web of systems.

ISO Technical Committee 184 Sub –committee 5 (TC 184/SC 5) is tasked with developing and overseeing standards related to enterprises. At its Plenary Meeting in Paris on April 23-24, 2009, ISO/TC 184/SC 5, in Resolution 611 (Paris 21) unanimously resolved that in order to explore the usefulness of Object Process Methodology for creating, designing, analyzing, and simulating models of its standards to improve the development, communication and understanding of these standards, SC 5 established Object Process Methodology Study Group (OPM SG). A call for expert mandated by this resolution asked the first two authors to collaborate on a terms of reference document for this study group that is to accompany the call of experts. The next milestone in this standardization process is a report of OPM SG to the next ISO TC 184/SC5 Plenary at the end of March, 2010, in Tokyo.

OPM SG has been tasked with the goal of investigating the viability of using OPM as a methodology and modeling language for the purpose of streamlining, formalizing, and explicating the standard ontology and glossary, and making enterprise-related standards more comprehensive, accessible, usable, and consistent both internally and across standards. Five specific objectives were stated. The first is to identify needs and requirements for elevating the levels of accessibility, inter- and intra-standard consistency, coverage of enterprise-related domains by standards, and other desirable features that a set of inter-related enterprise standards should exhibit. The second objective is to examine problems and missing integration or verification activities in current practices for developing and maintaining enterprise standards. Another objective is to elicit requirements from a modeling language perspective and examine advantages and disadvantages of current possible conceptual modeling language candidates that potentially meet the requirements, including (but not necessarily limited to) SysML, PSL (ISO 18629), BPMN, and OPM. Finally, using examples, lessons need to be learned and generalized in modeling of ontology and glossary definitions, detection of inter- and intra standards inconsistencies, evolving a set of a Web-accessible set of model snippets to be used as standard building blocks for enterprise architecture, and applying model snippets in an actual enterprise architecture.

The rest of the paper is organized as follows: Section 2 surveys related work in the fields of text processing and requirement engineering. Section 3 presents an example of processing International Standard IEC/FDIC 62264 (Enterprise-control system integration) [2]. In Section 4 we describe overall specification modeling stages. Section 5 contains a description of MBASE – Model-Based Authoring of Standards Environment that is used to support the task of Modeling Enterprise Standards with OPM. Section 6 concludes the merits of the proposed methodology.

II. Related work

Existing approaches for model-based representation of technical text and requirements modeling are not yet ready for prime-time application as they are mostly intended for narrow fields and purposes, although much effort is put into requirement engineering and bridging the gap from requirements to architecture [3]. Constrained languages, such as Attempto Controlled English (ACE – http://attempto.ifi.uzh.ch/site/) have not yet gained extensive spread because of usability issues and low accessibility to non-experts.

Numerous works, e.g., [4], [5], [6], discuss transforming natural language to code. Code-from-text generation approaches are generally very inflexible, not general and not expressive enough.

Another related field of intensive research is knowledge representation and ontologies. Examples include medical dictionaries, software-related repositories such as the ADOM—Application-based DOmain Modeling approach [7] and CCTS—Core Components Technical Specification [8], which defines meta models and rules necessary for describing the structure and contents of conceptual and physical/logical data models, process models, and information exchange models.

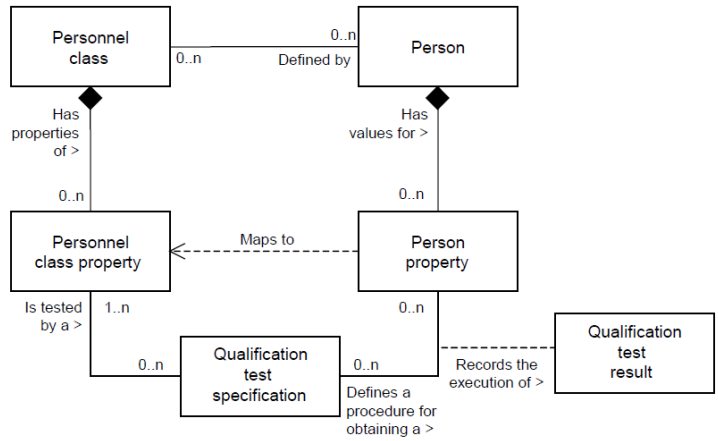
Text	Figure
The personnel model contains the information about specific personnel, classes of personnel, and qualifications of personnel. Figure 14 illustrates the personnel model. This corresponds to a resource model for personnel, as given in ISO 15704 and ISO 15531-1	

Figure 1: Corresponding text and figure fragment of paragraph 7.5.1.1 – Personnel Model of ISO/IEC 62264

Our approach incorporates existing ontologies and provides an extensible framework for ontology creation. Adopting ideas of SMART [9], we review and extend its principles to establish an OPM-based technical specification authoring methodology.

III. From text-based to OPM model-based standards: IEC 62264 as a case in point

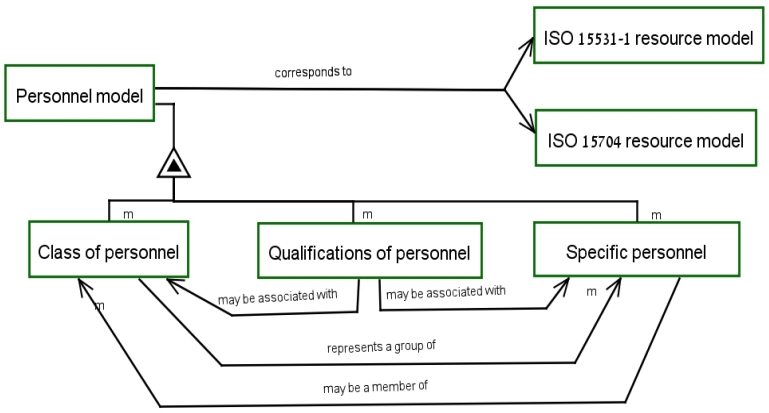
At the heart of our proposed solution is the claim that formal documents of technical nature that specify complex systems in general and standards in particular can be verified and validated using a constrained, standard subset of English.

Following a discussion with the Chair of SC 5 regarding the use of OPM to examine the restructuring of ISO/IEC 62264, we have proposed at the 2009 SC5 Plenary to focus on ISO/IEC 62264 for the following reasons: (1) it is a joint effort of ISO, IEC, and ISA; (2) it is currently under revision; and (3) it has seen success in the marketplace. Those in attendance at the 2009 SC5 Plenary concurred in the choice. The standard has four published parts and a fifth one in preparation, so it provides ample material for different approaches to the use of OPM as a means for analyzing the integration and interoperation of standards. ISO/IEC 62264 has a hook for enterprise architecture considerations that are part of the SC5 charge. Currently, ISO/IEC 62264 is using UML models to express the interface between ERP and MES applications, so a model framework exists to compare with the normative textual descriptions. To illustrate our motivation, we start with the following example. Consider the text and figure fragment of paragraph *7.5.1.1 – Personnel Model* of the ISO/IEC 62264 Standard in Fig. 1.

This paragraph illustrates some typical problems of combining free text with graphic specifications:

- Inconsistency between figure notation and notation in text: e. g., specific personnel (text of this paragraph) vs. Person (in the model and later in the text) or qualifications of personnel (in the text of this paragraph) vs. Person property (in the model and later in the text).
- Incomplete text (information in the model is not present in the text): e. g., the relation "records the execution of" between Qualification test result and Person property.
- Incomplete figure (information in the text is not present in the figure): e.g., correspondence to ISO 15704 and ISO 15531-1.

Only a few of these issues are resolved later in the standard's text, while the majority must be inferred from

Text	Figure
Automatically-generated Object-Process Language (OPL) paragraph Personnel model exhibits many Specific personnels, many Class of personnels, and many Qualifications of personnels. Specific personnel may be a member of many Class of personnels. Class of personnel represents a group of many Specific personnels. Qualifications of personnel may be associated with Class of personnel. Qualifications of personnel may be associated with Specific personnel. Personnel model corresponds to ISO 15531-1 resource model. Personnel model corresponds to ISO 15704 resource model. Manually tweaked OPL Personnel model corresponds to ISO 15704 and ISO 15531-1 resource models and contains the information about Specific personnel, Qualifications of personnel and Classes of personnel, including: • Class of personnel, which represents a group of many Specific personnel. • Specific personnel, which may be a member of many Classes of personnel. Qualifications of personnel may be associated with Class of personnel and/or with Specific personnel.	 **Figure 2: Model-Based version of the text in Fig. 1**

context. This situation can be avoided if we move from text-only to a model-based representation for standards.

OPM is bimodal, i.e., it has two equivalent representation, graphic and textual, which are derivable from each other. An OPM model-based expression of the content of a standard should enable not only checking and establishing consistency between the graphic and textual representation, but also the ability to implement and deploy tools for machine processing of standard text, automatic links among ontology entities, automated consistency checks, and examining adherence of field implementations to pertinent enterprise standards.

The basis of the OPM model-based approach is an extendable central OPM model of the domain's ontology that can be shared by all the standards related to the same domain or domains of sufficient similarity. This comprehensive and multi-disciplinary framework serves as a shared Web-based repository of normalized OPM-based model modules, called snippets, for the evaluation of international standards in the context of enterprise architecture and design. The central ontology OPM model can link terms and definitions, frequent phrase structures, business rules, enterprise design patterns, best practices, and more.

To enable implementing this approach, we are developing a standards authoring software environment, enhanced with natural language processing tools, with tools for editing and transforming existing standards from their current text-based form to their OPM model-based form, and for authoring new structured model-based elements for filling gaps in existing standards. In this environment, a standard is coupled with its model. This coupling inherently guarantees text-model consistency. Any change in a standard's text is reflected in its model and vice versa, so that both are fully consistent and interchangeable at all times.

As a proof-of-concept, we converted the text and figure for IEC 62264 paragraph 7.5.1.1 – Personnel Model (see Fig. 1) to an OPM-based structured form, shown in Fig. 2. The right column shows the Graphical OPM Model – Object-Process Diagram (OPD). The Structured Text column on the left has two parts: The automatically-generated Object-Process Language (OPL) paragraph, which is too mechanical to be left as is in a standard, followed by a manually tweaked version of this OPL paragraph, which can well be incorporated into the standard.

Each one of the two text paragraphs conveys complete information in a consistent form, so that the text is fully aligned with the model. The text is composed of simple, light, unambiguous sentences that, in addition to its simplicity and explicit nature, are also likely to significantly facilitate

automated, yet reliable, translations to natural languages other than English. Further detailed information, which causes confusion in the original specification, is hidden in in-zoomed paragraphs for Specific Personnel, Qualifications of Personnel and Classes of Personnel.

IV. SPECIFICATIONS MODELING PROCESS

Fig. 3 is an Object-Process Diagram (OPD) which provides an overview of the complete semiautomatic process of OPM-based specifications formalization. The OPM-Based Specifications Modeling system is operated by a domain Expert with the aid of MBASE environment. The system performs a process of converting specifications (free-text documents) into a structured OPM Model-Based form. This conversion is based upon the OPM-Based Ontology Model identified above.

Fig. 4 shows the details of the process. First, during the Natural Language Processing stage, source text documents are converted to Analyzed and Marked-Up form. Further, the OPM-Based Specification Modeling process yields the raw OPM Model-Based Specification model and structure fragments. After OPM Model Reviewing, we get the desired reviewed OPM Model-Based Specification. As a by-product, we evaluate, review, and enhance the ontology we used for the process.

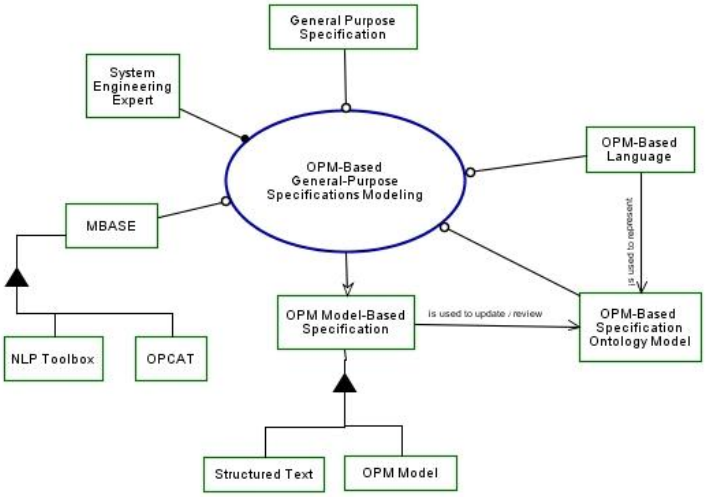


Fig. 3: General (top-level) OPD of the OPM-Based General Purpose Specifications Modeling with its agents, instruments and results.

V. MODELING SPECIFICATIONS WITH MBASE

To support analysis, synthesis, and conversion of standards, we have built a proof-of-concept MBASE – Model-Based Authoring of Standards Environment.

A document in MBASE is coupled with a corresponding OPM model. The coupling is based on paragraphs consisting of simple, unambiguous sentences and their counterpart model fragments that convey exactly the same information.

This coupling inherently provides text-to-model consistency, such that making changes to the text triggers changes to the OPM model and vice versa, making the graphics and its associated text interchangeable and fully consistent at all times.

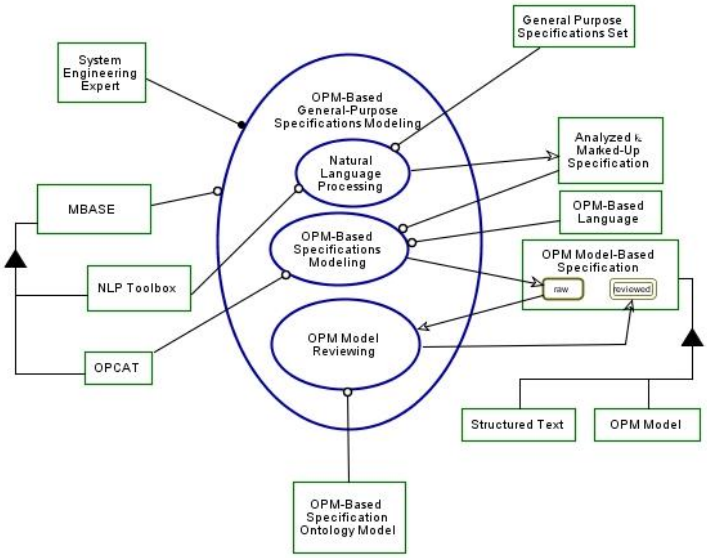


Fig. 4: Refined (second-level) OPD of the OPM-Based General Purpose Specifications zoomed in, showing the details of the process.

MBASE facilitates making technical documents humanly readable and writeable without compromising their formality, rigor, consistency and completeness following two major routes: backward and forward. In the backward direction, MBASE is used for reviewing and improving existing specifications, notably enterprise standards, from their current text-based form to an OPM-based form than can be graphical and/or textual. In the forward direction, MBASE is a prime support environment for authoring new model-and-text-based specifications of enterprise standards in particular and other system specifications in general.

The current MBASE implementation has the following capabilities:

1. Pre-processing and data import/export, including extraction of structure and keywords from documents' tables of contents, indices, glossaries, etc.
2. Natural Language Processing, for which tools for sentence simplification, parts-of-speech tagging, semantic similarity analysis and text modeling are integrated into MBASE.
3. Semantic analysis: Object-process-link heuristics and phrase repository, as well as text-to-model consistency checks.
4. Editing: Syntax highlighting, phrase completion, smart tips and snippets.

VI. CONCLUSION

An OPM model-based approach for text processing is presented, along with MBASE software tool for enabling text-

model duality and equivalence. This equivalence provides for sharing technical documents that are formal and expressed bi-modally in both text and graphics.

At present we are analyzing in depth ISO/IEC 62264 standard as part of OPM Study Group activity, appointed by the ISO TC 184/SC 5. The results are good so far, generally achieving the stated goals of streamlining, formalizing, and explicating the standard ontology and glossary, and making enterprise-related standards more comprehensive, accessible, usable, and consistent both internally and across standards. An extensive report on related work is to be presented in ISO TC 184/SC 5 Annual Meeting in Tokyo in March 2010.

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