

A MDD Approach for Modelling Web Accessibility

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Abstract

Accessibility requirements must be considered in Web applications development processes. A domain-specific metamodel for Web accessibility is introduced in this paper as a way of modelling aspects of accessibility. This metamodel could be used in techniques offering by Web Engineering methodologies, respecting their domain-specific metamodels for each method and used in MDD development environments. MDA standards such as MOF and tools such as EMF have been used. This proposal is included in AWA (Accessibility for Web Applications), a methodological framework for including accessibility in Web applications.

1. Introduction

The web offers many services including job searches, on-line education, documentation, news, games, leisure, administrative management, etc. However, all of these types of services are not accessible to all of us. Many web sites present barriers which make their access very difficult, and in some cases impossible. The users with the biggest problems are those with disabilities, but accessibility barriers affect a wider range of users and use contexts as well. For this reason, web access should be assured for any person, regardless of how he or she may access it.

From a business point of view, there is a generalized idea that accessibility means higher costs and problems due to a lack of knowledge in this area. Consequently, accessibility is not taken into account in the processes of web application development. However, accessibility not only assures access but contributes to many benefits, such as an agile maintenance, scalability with new business lines, better positioning in search engines, etc.

Accessible development implies some present difficulties: cost previsions, which method to follow to include accessibility criteria in the process, how the artefacts change from the client and the organization, how the roles vary in the development group, how to include

accessibility in the modelling, etc. These difficulties, amongst others, make accessibility development very difficult.

There are mechanisms for facing this situation: directives, norms, legislation and standards which identify the problems and help to design web pages in an accessible way. But from a software engineering point of view, there is no framework which integrates accessibility parameters in the whole life cycle of a web application. With this motivation, AWA (Accessibility for Web Applications) was created. AWA provides a framework for the development process of software in accessible web applications. This framework offers certain flexibility so that it can be adopted by organizations, independently of the methodology and processes which they may follow in their developments. In this work we show a detailed AWA module for giving support to methods of web engineering with respect to how to include accessibility aspects in the models, following a Model Driven Development (MDD) focus.

In section two we review related studies which consider accessibility from an Engineering perspective. AWA is described in Section 3, showing the proposal for how to model accessibility. The last section includes our conclusions and ideas for future research.

2. Related work

In the accessibility processing in the development processes, technological, human and legislative aspects must be considered, and from there, related works from numerous disciplines have been considered. In standardization, the W3C [1] must be highlighted along with the Web Accessibility Initiative (WAI) [2]. WAI includes documentation of suggestions on how to use the guidelines in the developments [3]. The Web Content Accessibility Guidelines (WCAG) [4] is one of the most important components, and is considered to be the official standard in the European Union. These guidelines appear in the majority of legislation worldwide. There are other laws such as DDA [5] in Australia or in the United Kingdom, Section 508 [6] in the USA, and in Spain there

is a standard [7], but they are all similar to those established by WCAG. However, the WCAG do not cover all situations, and the resources can be inaccessible, even when they adjust completely to the directives WCAG [8]. The WCAG 1.0 is a referential version, although the approval of the WCAG 2.0 is foreseen for the latter part of 2008, elaborated with a different focus in comparison with WCAG 1.0.

There are many relevant studies based on WCAG guidelines, most of them dealing with the accessibility evaluation [9] [10] the definition of metrics [11], and studies where indications on how to use the WCAG guidelines [12] are given. But no approximations on adaptability of WCAG have been found as a framework for the development process in the whole life cycle.

There are peculiarities in the area of accessibility, closely related to usability, which lead us to consider the techniques of the disciplines which deal with the user's experience, such as the Human-Computer Interaction (HCI). Along these lines there are studies which demonstrate the relationship between usability and accessibility [13] [14], others establish a framework for designing the introduction of accessibility in the User Centred Design (UCD) methodologies, applying techniques of usability [15] [16]. There are proposals on usability integration in the development process of software engineering that discuss accessibility [17], but they do not consider it in its integrity or in the whole life cycle of the application.

The related work of web semantic technologies such as XML, ontology, etc. have been found and resources are marked according to accessibility criteria. The Semantics Design Method (WSDM) has an ontology developed in the context of accessibility for the visually impaired [18]. In this scope there are works of formalization of guidelines WCAG [19] and others that offer direct access with adaptability contents following the standard models of "Access for all" used in e_learning platforms [20].

In the area of web engineering, accessibility is referred to in literature [21] [22], sometimes considered as part of usability [23]. There are several projects that consider accessibility, such as the WebML method [24] which focuses on user friendly and efficient access in the recovery and navigation of the information for a web site, but not how to carry out the accessibility model according to the WCAG standard which covers important and necessary technical aspects so as to avoid access barriers, or a work of the evaluation for the web applications, taking into account only some aspects of accessibility to offer text versions as alternative for contents with images [25]

From a research perspective, there is the recently created WUANet network [26], framed as an activity of "International Society for Web Engineering", in which

some areas of accessibility are starting to include accessibility in web engineering.

The diversity of active methods in the web engineering has led to the association of methods in a joint project [27]. This project MDWEnet is a initiative started by a group of researchers working on model-driven Web Engineering (MDWE) and want to develop common tools and define transformations between models following the Model-Driven Engineering [28]. This idea has been followed in this work through the abstraction mechanisms that MDE proposes to include accessibility requirements.

3. AWA: Accessibility for Web Applications

AWA (Accessibility for Web Applications) want to offer a domain specific methodological framework for the development of accessible web applications, which covers the whole life cycle. The main points are:

Integration in different methods

The development of accessible web applications does not require specific methodology in itself; this only makes sense when the methodological approach includes accessibility criteria. In this way, the purpose of AWA is to offer flexibility in its use so that it can be adopted by different existing methods which comply with the minimum conditions required.

Based on various disciplines

On one hand, AWA is based on web engineering which provides specific modelling techniques as well as development processes some of which are based on code generation, and some on Model Driven Development (MDD). On the other hand it can also be based on the traditional software engineering approaches, which although they are heavy processes, they provide methodological support for characteristics of the development team and project management which are useful and necessary for accessibility processing.

A User-Centred Approach

Both the software engineering as well as the web engineering approaches are very much centred in the architecture, which are normally very distant to the user. Thus, to achieve a rapprochement with the user the necessary requirement in this proposal is to have an inclusive User Centered Design (UCD), with the use of usability techniques proceeding from HCI discipline.

Compliance with standards

In AWA there is a requirement to follow standards in the web offered by W3C (WCAG, XHTML, CSS, etc.), as well as in the development processes making use of Object Management Group standards (OMG) [29]:

Unified Modelling Language (UML), Meta-Object Facility (MOF) [30] amongst others.

Web accessibility is more than the WCAG

AWA considers web accessibility in various dimensions. Thus, the WCAG standards not only have to be understood, but will be globally considered, giving great support to the capture of requirements in order to identify other requirements, as well as those from WCAG and other derivations to keep in mind such as: the inclusion of interactivity with the user in development, to include aspects of modelling accessibility, include plans and management of the accessibility in the organization, accessibility monitoring, etc.

3.1. Structure of the AWA

AWA provides a methodological framework with: (1) a specific accessibility process so that it can be adopted by other processes, indicating activities, artefacts and their sequence in the different phases of integrating accessibility criteria, and (2) support for the modelling by using the techniques provided by web engineering methods, as well as MDE, the focus of this paper.

The accessibility achieved in developing a web application will be greater if all the mechanisms of accessibility defined in AWA are implemented; if they are only partially applied, then the web accessibility achieved will be limited.

Thus, AWA is structured around two modules in order to incorporate accessibility mechanisms as is explained below.

3.1.1. AWA-Process

The process view is based on a wide support for capturing accessibility requirements, including, apart from Non-Functional Requirements (NFR) which are considered in the majority of approaches, the Functional Requirements (FR) of accessibility in the development process. In this way, related to process accessibility different typologies of requirements are included such as: following the WCAG standard, assuring the quality and management of the accessibility during the process, an accessibility plan in the development team, an accessibility policy in the organization and finally, evaluation and monitoring of accessibility.

This module is not explained in this paper but briefly, the traditional software methodologies are followed, and specific requirements; phases, artefacts, roles, etc., are offered in the development process as well. Moreover, UML is used along with techniques proceeding from the HCI area, especially those dealing with usability.

3.1.2. AWA-Modelling

With respect to the methodological view, it is important to use the modelling techniques that Web engineering methods offer us as well as the MDA framework [31]. The objective is trying to use any one of them, without applying a specific method, in order to be able to include accessibility aspects in the modelling of the content, presentation and navigation models of the method concerned. The strategy in AWA, as shown in Figure 1, consists of offering a CIM, domain-specific metamodel for the Web accessibility, denominated AWA-Metamodel, so that it can be used by these models.

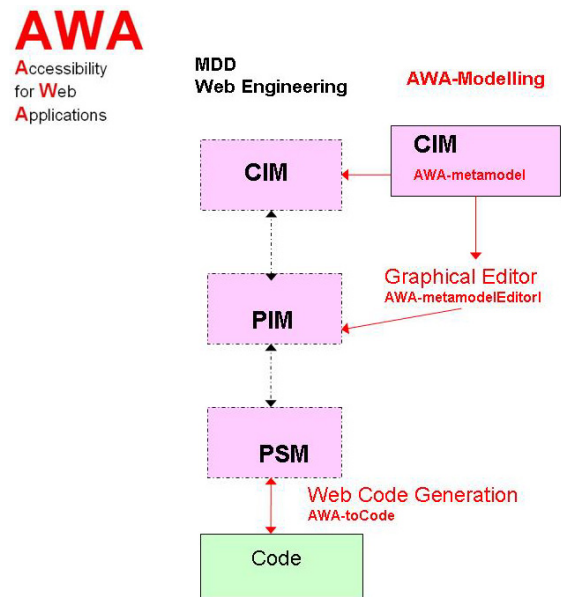


Figure 1. AWA for MDA development process.

AWA-Metamodel can be used to build PIM models of web engineering methods wherever it is desirable to include aspects of accessibility in the design of its applications. To give support to the designer, it provides a graphic editor called AWA-MetamodelEditor, so the designer may include objects on AWA-Metamodel for their PIM models in a transparent way.

For the final web code generation, which includes aspects of accessibility that have been considered in AWA-Metamodel, there is the AWA-toCode resource. The strategy used is to generate code from the PSM models in accordance with the method by using a transformation Model-to-Text (M2T).

Up until now, according to research that has been carried out, the AWA-toCode will not be completely independent of the method. It must be understood as a transformation of PSM into web code. This transformation must be kept in mind together with aspects

of the presentation, navigation and content models integrated into the method used in their application, in order to achieve the highest degree of compliance with accessibility in accordance with WCAG Web resulting code.

3.2. AWA-Metamodel

The designer has to know about accessibility issues if WACG standard is to be considered in the modeling phase. We want to enclose this knowledge into a domain model to serve as a bridge for the web application analyst and designer, modelling and describing the requirements and how to use them later in the system.

Concepts based on the WCAG standard and derived restrictions have been modelled in the AWA-Metamodel. The purpose is for these accessibility aspects to be encapsulated in the whole development cycle.

Technical aspects of getting valid and accessible web code according to standard WCAG (aspects that can be automated) have been modelled, but this metamodel does not deal with aspects of accessibility valued by the human factor. For that purpose, AWA offers other mechanisms. With the use of AWA-Metamodel full accessibility is not completely obtained but the inclusion of knowledge in models increases levels of accessibility as do WCAG guidelines. Moreover, the application of AWA-Modelling provides sufficient knowledge to meet the checkpoint applied in AWA (shown in Table 1), in relation to the different levels: A, AA and AAA according to WCAG.

	A	AA	AAA
WCAG 1.0	7/12	9/19	9/17

Table 1. Ratio of achieved checkpoints according to WCAG.

The UML metamodel, MOF, has been chosen as a tool for modelling purposes so that it can be used by other methods which follow the OMG standards. In this way, modelling aspects of accessibility can be used and at the same time the specific-domain metamodels of the method concerned are respected. With this aim, AWA offers a specific metamodel of the web accessibility domain. Depending on the method, it will be necessary use Model_to_Model (M2M) transformations.

3.2.1. Modelling the WCAG

To obtain a CIM regardless of the method, concepts and their relationship to the standard WCAG, along with other aspects of accessibility, have been modelled; it is necessary to model requirements, those concepts which

hold properties that define objects to be included in the PIM models.

Concept	properties	WCAG 1.0	WCAG 2.0	Associations
DOCTYPE	lang	4.3	3.1.1	ROOT (1..1)
BODY		3.2	4.1.1	ROOT (1..1)
HEAD	title		2.4.2	ROOT (1..1)
META	name/content	13.2		HEAD (1..*)
HEADING	level	3.5	1.3.1,2.4.10	BODY (1..*)
	contentDescription		2.4.6	
LINK	css	3.3, 6.1,14.3	1.3.1,1.3.2, 1.4.1,1.4.4,1.4.5, 2.4.7,1.4.8, 1.4.9	HEAD (1..*)
	href	3.2	4.1.1	
	type			
HIPERLINK	href	3.2	4.1.1	BODY (0..*), IMAGE (0..1)
	accesskey	9.5	2.4.1	
	tabindex	9.4	2.4.3	
	title	13.1	2.4.4, 2.4.5, 2.4.6, 2.4.7, 2.4.8, 2.4.9	
	target	10.1	3.2.1, 3.2.2, 3.2.5	
	contextDescribe		2.4.4, 2.4.9	
	hreflang		3.1.2	
IMAGE	src	3.2	4.1.1	BODY (0..*)
	alternativeText	1.1	1.1.1	
	longAlternatedesc	1.1	1.1.1	
MEDIA	uri	3.2	4.1.1	MEDIA (1..*), BODY (0..*)
	AlternativeCaption	1.3, 1.4	1.2.2, 1.2.4	
	alternativeAudioDesc	1.3, 1.4	1.2.3, 1.2.5, 1.2.7	
	alternativeText	1.3, 1.4		
	alternativeSignLang		1.2.6	
TECHNICAL MEDIA	alternativeFullText		1.2.3	MEDIA (1..*),
	format	11.3		
	duration	11.3		
	content type	11.3		
LANG	name	4.1	3.1.2	
	content	3.7	1.3.1, 1.3.4	
QUOTATION	caption			BODY (0..*)
	summary	5.5		
THEAD_TABLE	contentIHead	5.1, 5.2	1.3.1	TABLE (1..*)
	abbreviation	5.6		
ROW_THEAD	contentRow	5.1, 5.2	1.3.1	THEAD_TAB LE (1..*)
LIST	type	3.6	1.3.1	BODY (0..*)
ITEM_LIST	content	3.6	1.3.1	LIST (1..*)
FORM	name			BODY (0..*)
	type			
FIELDSET	legend			FORM (0..*)
LABEL_FORM	for_id	10.2, 12.4	1.3.1	FORM (1..n), FIELDSET (0..1)

Table 2. Concepts to be modelled following WCAG.

As mentioned before, the current version of reference is the WCAG 1.0, but it has also been taken into account for the next launch of the WCAG version 2.0.

As a first approximation some meta-objects based on a study on the standards have been identified, as shown in Table 2.

For instance (see Figure 2), several constructs have been defined in MOF to support the abstraction of web accessibility concepts, including one for the concept of image that includes required attributes to enable it to meet the standard WCAG such as the "AlternativeText" "AlternativeLongText" (1.1. of WCAG 1.0 and 1.1.1 of WCAG 2.0) and others such as "src".

A graphic element representing an image (MOF meta-object) has been defined in the AWA-Editor, and may be

included in the PIM models, which contain the knowledge included in AWA-Metamodel necessary for the web code generation in the final phase.

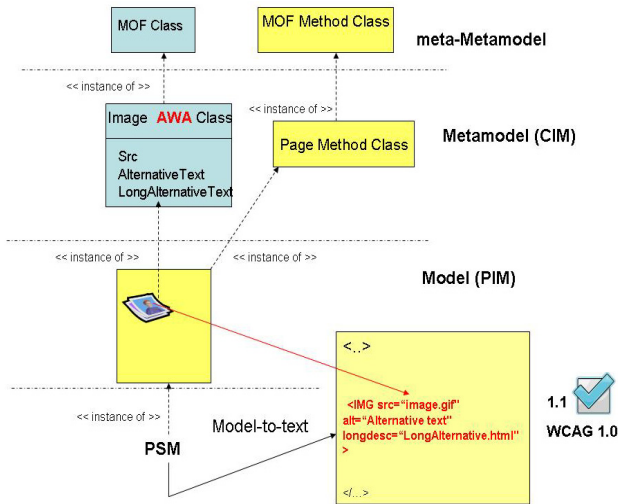


Figure 2. Image concept instance in MDA.

Aspects of accessibility not included in the standard WCAG, have also been included in the AWA-Metamodel, since they are thought to be important properties following research carried out in AWA, such as the attribute “type” of LINK construct, or the TECHNICAL_MEDIA meta-object.

The domain experts use their own vocabularies to specify the CIM, however, in this proposal the meta-objects are familiar with any web applications designer using them in a easy way, but the requirements and how to use them are described. Thus, the designer will be use instances of usual images, tables, multimedia elements, etc. but an alternate content or semantic information will be required to comply with the checkpoints of WCAG.

3.2.1. AWA-Modelling Tool

To give CASE support and more interoperability, due to the fact that it is based on standards, the Eclipse Modelling platform has been used. For the metamodel, EMF (Eclipse Modelling Framework) [32] with Ecore language has been used. It has been designed with three packages: one for modelling concepts of the web "page", another corresponding to the web "head", and finally the package for the web "body" as Figure 3 shows (Ecore metamodel).

The graphical AWA-MetamodelEditor editor from the AWA-Metamodel, has been made using GMF plug-in (Graphical Modelling Framework) [33]. Finally, a code generator at the end of the MDA process will be offered,

translating these accessibility concepts included in the AWA-Metamodel into a valid and accessible web code.

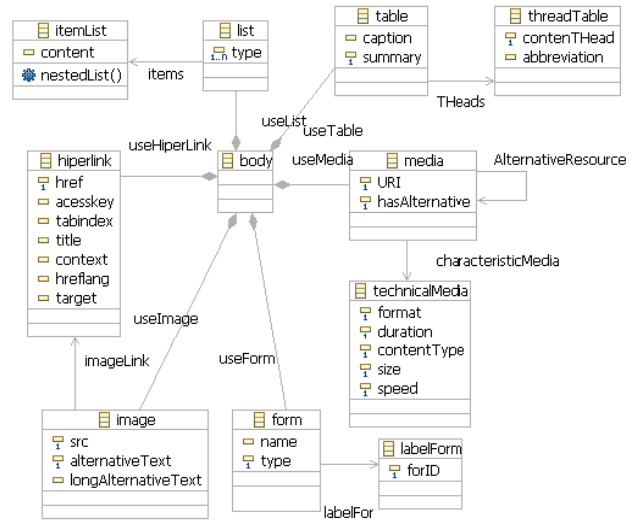


Figure 3. Ecore diagram of web body package.

AWA-Modelling can be applied in the methods that follow standards of the OMG, and is easier than using Eclipse tool. However, EMF provides the mechanism for storing models in XMI format which can be exchanged with other tools.

4. Some conclusions and future work

Web accessibility problems are increasing with the rapid advance of web technologies and how these are being used. We also find ourselves facing a crisis in the development of web sites, where there is a tendency towards ad-hoc designs which in most of the cases do not follow any methods or standards. This view complicates the establishment of procedures on how to include accessibility criteria from the start of the development process. From an engineering perspective, the solution should be guided towards the training of those professionals who develop web sites with methods which help and guide the processes in order to achieve the objective of accessibility.

From this perspective we question whether or not to integrate mechanisms of accessibility into the software development process following web engineering methodologies.

A domain-specific metamodel for the Web accessibility, AWA-Metamodel, as a first approximation, is introduced as a solution to be adopted by different existing methods.

In future research, we will work on the AWA definition and validation. Related to the focus of this

paper, we would like to apply AWA-Modelling to OOWS Model-Driven Approach [34], because OOWS is a web engineering method that ensures the minimum conditions, such as standards fulfilment, required by AWA.

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6. References

- [1] W3C, <http://www.w3.org/>
- [2] Web Accessibility Initiative (WAI), <http://www.w3.org/WAI/>
- [3] WAI Resources on Managing Accessibility, 2005, <http://www.w3.org/WAI/managing.html>
- [4] Web Content Accessibility Guidelines (WCAG), <http://www.w3.org/WAI/intro/wcag.php>
- [5] Americans with Disabilities Act (ADA), 1990, <http://www.ada.gov/>
- [6] United States Laws, Overview of the Rehabilitation Act of 1973 (Sections 504 and 508), 1998, <http://www.webaim.org/articles/laws/usa/rehab.php>
- [7] AENOR, Spanish technical standards. Standard UNE 139803:2004: Requirements for WebPages accessibility. <http://www.aenor.es>
- [8] DDC report The Web Access and Inclusion for Disabled People, 2004, <http://www.drc.gov.uk/publicationsandreports/2.pdf>
- [9] Abascal J., Arrue M., Fajardo I., Garay N. and Tomás J., The use of guidelines to automatically verify Web accessibility, Universal Access in the Information Society , 2004, Springer
- [10] Xiong J., Farenc C., Winckler M. Analyzing Tool Support for Inspecting Accessibility Guidelines during the Development Process of Web Sites. 1st Workshop on Web Usability and Accessibility. WISE 2007, LNCS 4832
- [11] Vigo M., Arrue M., Brajnik G., Lomuscio R., Abascal J., Quantitative Metrics for Measuring Web Accessibility. 2007. ACM international cross-disciplinary conference on Web accessibility (W4A).
- [12] Nykänen O., Kaikuvuo I., Adapting Web Accessibility Guidelines to an Application Development Process. 2006. International Design for All Conference.
- [13] Petrie, H. and Kheir, O. The relationship between accessibility and usability of websites. 2007. Conference on Human Factors in Computing Systems. CHI '07. ACM
- [14] Moreno, L., Castro, E., Cuadra, D. and Martinez, A. Framework for Developing Accessible and Usable Web Applications. 2007. Handbook of Research on Public Information Technology, G. David Garson.
- [15] Henry, Shawn Lawton. Just Ask: Integrating Accessibility Throughout Design. 2007. Madison, WI: ETLawton. www.uiAccess.com/justask/
- [16] Moreno, L., Martinez, P. and Ruiz, B. Inclusive Usability Techniques in Requirements Analysis of Accessible Web Applications, 1st IWWUA WISE 2007, LNCS 4832
- [17] Granollers, T., MPlu+a. PhD Thesis. (2004). Universidad de Lleida. Spain
- [18] Plessers, P., Casteleyn, S., Yesilada, Y., De Troyer, O., Stevens, R., Harper, S., and Goble, C. 2005. Accessibility: a Web engineering approach. 14th WWW '05. ACM
- [19] Moreno, L., Martinez, P., Contreras, J. and Benjamins, R. Towards Accessible Semantic Web Applications. 2005. Conference on Dublin Core and Metadata Applications.
- [20] IMS Global Learning Consortium, 2004 AccessForAll Meta-data Guide Version 1.0 http://www.imsglobal.org/accessibility/accmdv1p0/imsaccmd_bestv1p0.html
- [21] Murugesan S. Web application development: challenges and the role of web engineering, Chapter 2 in Book: Web Engineering, Rossi, G. et al. , 2008, Springer.
- [22] Gaedke M. and Meinecke J., The web as an application platform, Chapter 3 in Book: Web Engineering, Rossi, G. et al. , 2008, Springer.
- [23] Kappel G.. Web Engineering The Discipline of Systematic Development of Web Applications. 2006. Edited by Gerti Kappel, Birgit Pröll, Siegfried Reich, Werner Retschitzegger, by John Wiley & Sons Ltd.
- [24] Ceri, S., Matera, M., Rizzo, F., and Demaldé, V. 2007. Designing data-intensive web applications for content accessibility using web marts. Commun. ACM.
- [25] Olsina L., Papa F., Molina H., How to measure and evaluate web applications in a consistent way. Chapter 13 in Book: Web Engineering Rossi, G. et al. , 2008, Springer.
- [26] ISWE, WUAnet (Web Usability and Accessibility Network). 2008. http://www.editthis.info/wuanet/Main_Page
- [27] Vallecillo A. et al, 2007. MDWEnet: A Practical Approach to Achieving Interoperability of Model-Driven Web Engineering Methods, 7th ICWE, Workshop Proceedings, Dipartimento di Elettronica e Informazione, Politecnico di Milano, Italy, p. 246 – 254.
- [28] Schmidt, D.C., Model-Driven Engineering, IEEE Computer Society. 2006. pp. 25 – 31.
- [29] The Object Management Group (OMG), <http://www.omg.org/>
- [30] OMG MetaObject Facility (MOF), <http://www.omg.org/mof/>
- [31] OMG Model Driven Architecture (MDA), <http://www.omg.org/mda/>
- [32] The Eclipse Foundation. EMF (Eclipse Modelling Framework) <http://www.eclipse.org/modeling/emf/>
- [33] The Eclipse Foundation. GMF (Graphical Modelling Framework) <http://www.eclipse.org/modeling/gmf/>
- [34] Fons J., Pelechano V., Pastor O., Valderas P., Torres V. Applying the OOWS Model-Driven Approach for Developing Web Applications. The Internet Movie Database Case Study. Chapter 5 in Web Engineering: Modelling and Implementing Web Applications, Rossi, G. et al. , 2008, Springer.

¹ www.cesya.es