# Enhanced Approach for Developing Web Applications Using Model Driven Architecture

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*Abstract*— **Creating of web application and corresponding information architecture is often associated with social informatics. It clearly lays at the crossing of the ICT and social sciences, especially because effective information architectures enable people to find content quickly, easily and intuitively. Model Driven Architecture (MDA) technique is initiated by the Object Management Group (OMG), based on separation of concerns. It describes the system functionality in platform independent model (PIM) and also describes the implementation of this functionality using platform specific model (PSM), where the transformation process from PIM to PSM is done automatically using QVT model transformation language. To overcome the large scale web application system complexity, model-driven web engineering is used to automate web application using models to describe web site in different abstraction level. The automation in existing web development methods could be enhanced using MDA technique. This paper provides proposed mechanism to enhance Web Site Design Method (WSDM) method by applying MDA technique. The proposed mechanism enhances WSDM from conceptual modeling approach to MDA modeling approach by profiling the conceptual model of WSDM with the new user-interest profile. This redesigned conceptual model is used as PIM model. The proposed mechanism adds generic PSM to the implementation model of WSDM. We use QVT model transformation language to automate the mapping specification from PIM to PSM. Our method is called *WSDM using MDA* (WSDMDA).**

*Keywords-Web Engineering; Model-Driven Engineering; MDA; Model Transformation; QVT*

## I. INTRODUCTION

### A. Web Engineering

To cope with the particularities that characterize Web applications compared to traditional software (desktop applications), researchers started working on the definition of methods for the construction of this kind of systems. These methods were not defined from the scratch; in fact, they were based on existing methodologies for traditional software development such as object oriented techniques. The main contributions of these new methods were the introduction of new abstractions to deal with modeling navigation and presentation concerns.

Many of methodologies in web engineering field follow software architecture framework called Model View Controller (MVC) [1] which separates the representation of information from the user's interaction with it. The simplified diagram of MVC in figure 1 shows three basic components that actually constructing the MVC architecture, while the User component has become unavoidable component to develop a complex web applications.
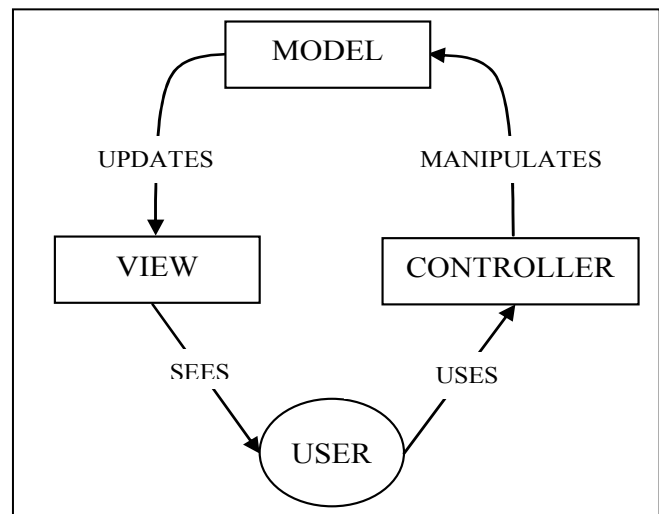


Figure 1. MVC – Simplified Overview

MVC framework is not just dividing the application into three basic kinds of components; it is also defines the communications between them.

- *Controller* can send commands to its associated view to change the view's presentation of the model (e.g., by scrolling through a document). It can also send commands to the model to update the model's state (e.g., editing a document).

- *Model* notifies its associated views and controllers when there has been a change in its state. This notification allows the views to produce updated output, and the controllers to change the available set of commands. A passive implementation of MVC omits these notifications, because the application does not require them or the software platform does not support them.

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- **_View_** requests from the model the information that it needs to generate an output representation to the user.

### B. Model Driven Architecture

Software development based on Model Driven Architecture (MDA) was endorsed and proposed by the Object Management Group (OMG) [2],[3],[4]. It is a realization of Model Driven Engineering (MDE) [5]. MDA is supporting ever-changing business environments by using effective tools to design complex systems, and keeping the software development cost (coding effort, time-to-market, etc.) at an acceptable margin.

MDA describes application requirements in Platform Independent Model (PIM) while represent the implementation aspects in Platform Specific Model (PSM).Then it applies mapping rules to transform PIM instances into PSM instances. This process is done automatically. Therefore an ultimate goal of MDA is to automate mapping from source model (conceptual model) to target model (solution model). The final step is delegated to code generator tools which automate the production of code [6]. In order to do that MDA is based on a set of OMG technologies such MOF [7], UML [8],[9], XMI [10] and QVT [11]. MOF [12] (Meta Object Facility) and UML (Uniform Modeling Language) are standard languages for modeling and metamodeling aspects while XMI (XML Metadata Interchange) is used for model exchange between tools and QVT (Query/View/Transformation) is used for the transformation activity.

Figure 2 describes the overall steps of system development using MDA approach. MDA system creation starts with the Computation Independent Model (CIM). It is a model that describes a system from the computation independent viewpoint that focuses on the environment and the requirements of the system. In general, it is called domain model and may be expressed using business models. To move from one level of system abstraction to another level, there must be a mapping specification process that specifies correspondences between the source model (CIM in this case) and target model. In general, mapping specification can be a model itself. The second stage in the sequence of system creation using MDA approach is Platform Independent Model (PIM). It is a model with a high level of abstraction that is independent of any implementation technology [13]. To implement the mapping (called transformation in this case) from PIM (as source model) to the target model there is a transformation engine initiative by OMG known as Query/View/Transformation (QVT-R), which is designed especially to automate the mapping from PIM to PSM. Platform Specific Model (PSM), placed in the third part of MDA system creation, it is a tailored model to specify the system in terms of the implementation constructs available in one specific platform. For that reason, depending on the type of platform (Programming Language, Operating System, or network), there can be more than one PSM. The last step of the system creation using MDA approach is the

code generation. There are many tools that have been designed to realize this step. However this step is out of this research scope.
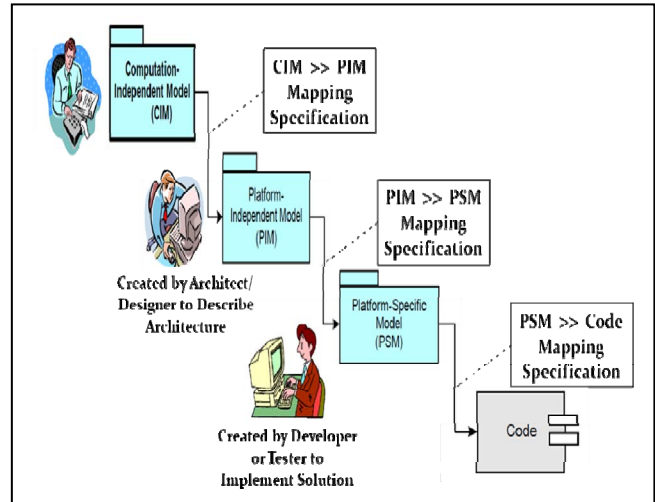


Figure 2. Steps Required to Create System Using MDA

### C. Paper Organization

The rest of the paper is organized as follows; section 2 describes WSDM as a first audience-driven web application development method. Section 3 reviews some works related to this research. Section 4 provides the proposed mechanism used to enhance WSDM and how it can be applied to existing WSDM architecture. Section 5 discuss and analyze the approach as a combination between WSDM and MDA. Conclusion and future work are presented in the last section.

### II. MOTVATION AND CONTRIBUTION

To dynamic system designers especially the designers of web applications, MDA has not been widely used. In recent years, there is an increasing demand to deliver the web application product to the market as fast as possible. As such the coding process for the complex web applications is becoming a tedious and error-prone [14]. There is a need to apply new approaches to the existing web application development methods to deliver web application systems faster than by the traditional methods.

As a contribution, this paper is proposing a mechanism to enhance one of the existing web application development methods by applying MDA technique. The proposed mechanism enhances WSDM from conceptual modeling approach to MDA modeling approach by profiling the conceptual model of WSDM with the new user-interest profile. This redesigned conceptual model is used as PIM. The proposed mechanism also adds generic PSM to the implementation model of WSDM. We use QVT model transformation language to automate the mapping specification from PIM to PSM. This enhanced method that combines WSDM with MDA is called (WSDMDA).

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### III. WEB SITE DESIGN METHOD (WSDM)

De Troyer and Leune [15] introduced a web application developing method called Web Site Design Method (WSDM). Later they evolved this method to include the semantic web concept, and renamed their method to Web Semantics Design Method (to keep the same abbreviation) [16].

WSDM not only provides modeling approach to enable web developers to create models to describe the web applications from different views and different abstraction levels, but it also provides a complete methodology to construct and generate the web applications. WSDM generates content-related annotation to make the content semantic explicitly displayed, and also generates structural annotation to describe the different structural element semantics in explicit way.

WSDM follows the audience-driven design philosophy. The requirements of visitors are taken as starting point to drive the content (or part of it) from these requirements. Visitors' requirements (interests) are collected from user navigation (behavior) path which some time called audience tracks, or collected from the home page contents.

Figure 3 shows a simplified view of the different phases in WSDM [16]:

- **Phase 1:** (Mission Statement Specification). This phase is used to specify the web application purpose (subject) identification, and to identify the targeted users.

- **Phase 2:** (Audience Modeling). In this phase, targeted users are identified and classified into audience classes, based on user requirements, constructing audience hierarchy according to a given characteristics.
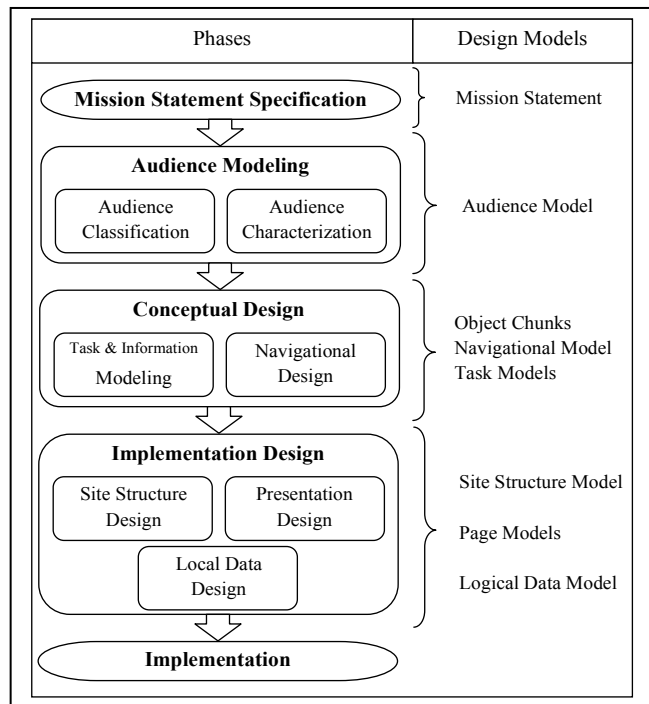


Figure 3.   Simplified View of WSDM Phases

- **Phase 3:** (Conceptual Design). This phase is to describe conceptual specification requirements of web application. Task & Information Modeling sub phase used to specify functionality and information for web application. In the Navigational Design sub phase, the navigational paths for all audience classes are specified.

- **Phase 4:** (Implementation Design) this phase contains three sub phases:

    **Site Structure Design:** It is to group and map conceptual structure of web application onto pages.
    **Presentation Design:** This sub phases is to specify the layout of web pages.
    **Logical Data Design:** this sub phase is used only if the web application need to process data from external sources (e.g. Databases).

- **Phase 5:** (Implementation) all information collected from the previous phases is used to generate actual implementation automatically.

Later, the semantic web concept [17] is applied to WSDM by De Troyer, Casteleyn, and Plessers [18] and [16] using Ontology Web Language (OWL) [19],[20]. We found that, these semantics are just used to annotate the web site content semantically without affecting the structure of the main method. For that we prefer to enhance only the main WSDM.

### IV. RELATED WORKS

Escalona and Koch [21] presented an approach which aimed to improve the development of Web Applications by specifying the web application requirement by taking into account both general characteristic of web applications and how web engineering deals with requirements. Hernandez et al [22] argued that automation is an effective way to reduce time and costs of web application testing. Software testers encode a set of test cases for the application in a scripting language, and use the script as input to an automated testing tool which executes the tests. If subsequent changes are made to the system, the test script provides a means for automatically performing regression testing to determine whether new errors were introduced into these previously tested components [23].

Retalis [24] provided an attempt for facilitating the conceptual design of web-based educational application by metamodeling their underlying content and navigational structure. His work is based upon (and also extends) the Object Oriented Hypermedia Design Method (OOHDM) [25] principles. The Unified Modeling Language (UML) serves the purpose of notation syntax and semantics for this meta-model.

Koch and Kraus [26] presented a first step towards a common metamodel for the UML-based Web Engineering (UWE) approach. The metamodel is defined as a conservative extension of the UML metamodel. They further discussed how to map the UWE metamodel to the UWE modeling constructs (UML profile) of the design method which was already presented in previous works. The metamodel and the mapping specification are the core of the

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extension of the ArgoUML [27] open source CASE-tool that they developed to support the UWE design notation and method.

This research is much related to one of the research by Schmid and Donnerhak [28]. They are taking Object-Oriented Hypermedia Design Method (OOHDM) as starting point to build their own method called OOHDMDA [29]. OOHDMDA redesigns the object model of OOHDM to use as PIM after adding Behavioral Semantics Model. PSM model is derived from the classes of behavioral model with well-defined semantics and targeted to servlet-Based platform.

As our proposed mechanism shall built in user-interest profile and generic PSM to develop web application, we found that WSDM method is suitable for our proposed mechanism because it can produce greater satisfaction and higher usability by producing attractive web sites with good design for different types of visitors and with different needs.

## V. PROPOSED MECHANISM

### A. *Proposed User-Interest Profile*

In our proposed mechanism, a new User-Interest Aware profile is added to extend the activity diagram metamodel of UML. The lower part of Figure 4 shows the proposed User-Interest requirements profile. We will add this profile to the conceptual model of WSDM to redesign it to be considered as PIM.
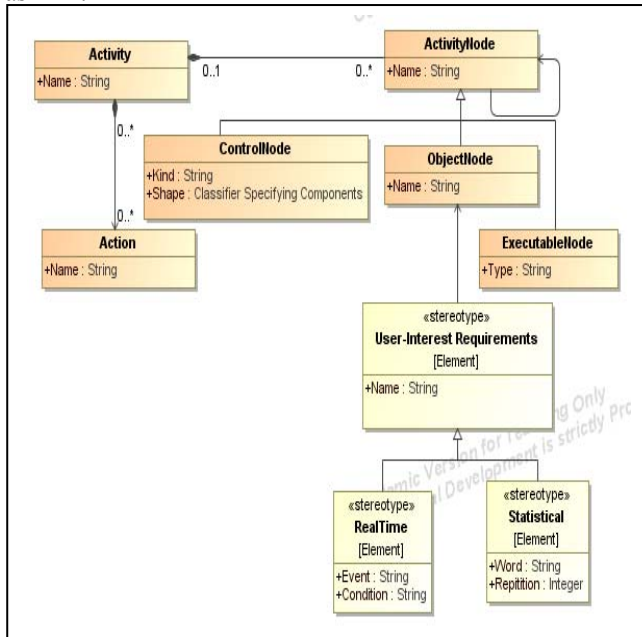
Figure 4.    Proposed User-Interest Profile

### B. *Proposed Generic PSM*

Figure 5 shows the proposed Generic Web Application Programming Language Model. We add this model to the implementation model of WSDM to reuse and consider it as PSM to use it with different web programming languages.
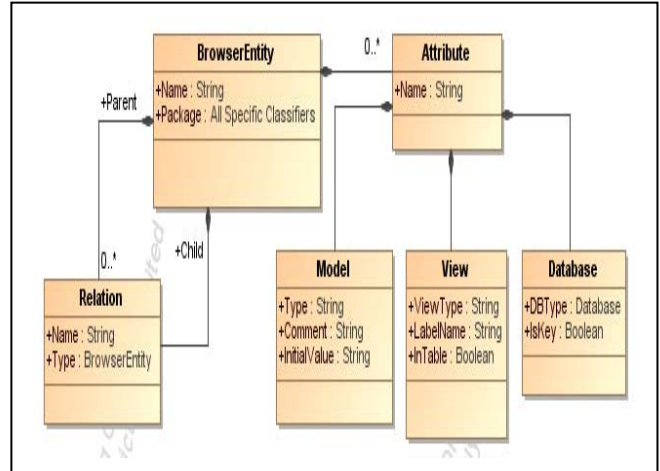
Figure 5.    Proposed Web Application Programming Language Metamodel

### C. *Applying the Proposed Mechanism to WSDM*

Figure 6 shows the complete proposed structure of WSDM using MDA (WSDMDA) by integrating the existing WSDM method with our proposed mechanism. WSDMDA is keeping all parts of WSDM (using white boxes), and adding the new components from proposed mechanism (using non-white boxes). Oval shaped objects are used to display each separated phase and to declare the flow of the WSDMDA execution.

The important part of WSDMDA is the redesigning of phase 3 and phase 4 to be considered as PIM and PSM respectively, and the executing of model transformation from PIM to PSM to fulfill the main objective of MDA.
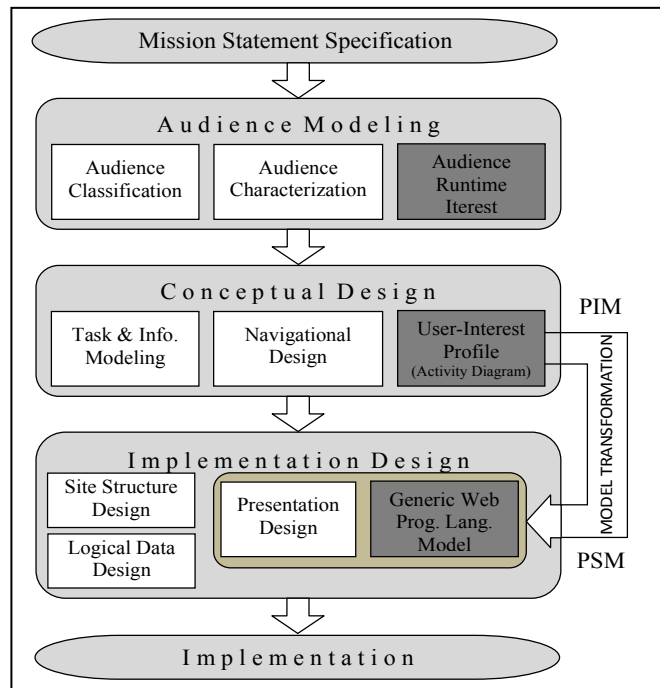
Figure 6.    The New Structure of WSDM Using MDA (WSDMDA)

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## D. Model Transformation

MediniQVT [30] is used to execute the mapping specification from PIM to PSM. MediniQVT language takes the PIM model, PIM model instance, and PSM model as input executing the code. The output from the code execution is the PSM model instance which is passed to the delegated tool to generate the complete code.

Figure 7 illustrates QVT code execution, while Figure 8 represents an example of model instance for the activity diagram model extending by user-interest profile as a part of PIM instance.
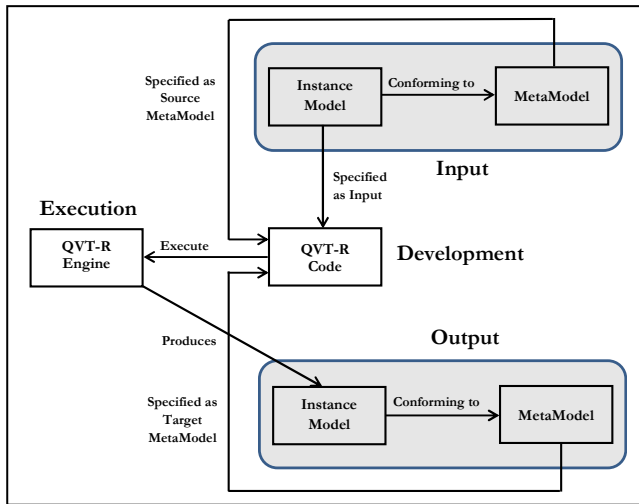


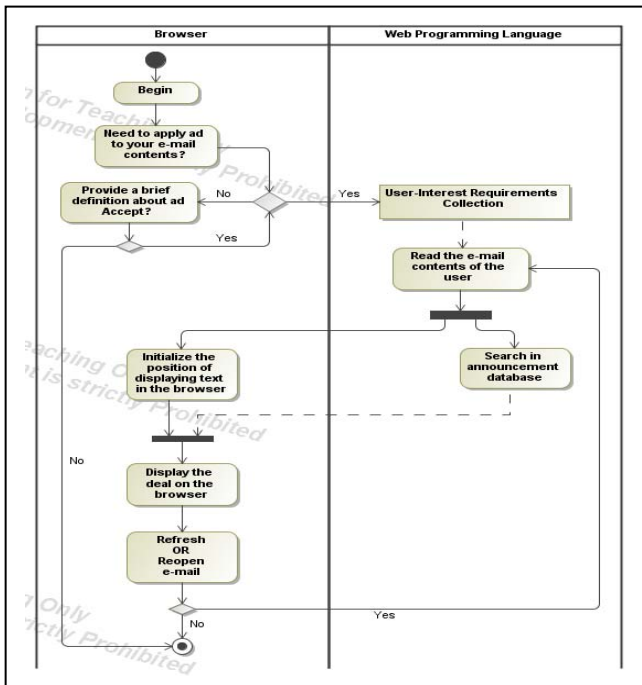Figure 7.   QVT Code Execution Illustration



Figure 8.   Part of PIM Instance Using User-Interest Profile

## VI.   DISCUSSION

The outcome of the proposed WSDMDA mechanism allows the old WSDM method to partially deal with dynamic web application systems instead of dealing totally with static ones. This is because the top part of the web site content will be changed according to the user interests, while the other parts will remain as described by the web designer.

User-interest profile is used during the run time of web application to display special items according to the web application contents; these items could be a promotion of new product, hot and interested topic in specific field, etc.

In the implementation design phase, the generic web programming language model makes WSDMDA suitable to be run on different platform (J2EE, PHP, or JSP) making the proposed mechanism more flexible. This is because the PSM in MDA technique is used as an interface to generate the code. For example if the PSM designed as an interface to PHP, the generated code will be a PHP code.

## VII.   CONCLUSION AND FUTURE WORK

WSDMDA is a new MDA-Based method to develop web applications. It is built on the existing Web Site Design Method (WSDM). WSDMDA is enhancing the existing method by applying the MDA approach to deliver the complex code of web applications faster than the traditional methods.

The idea behind MDA is both simple and grand [31], WSDMDA is beneficiating from this idea by trying to decouple the definition of application systems functionality (in PIM) from technology platform that it runs on (in PSM). The objective from this decoupling is to ensure that the functionality of the system can be preserved even there are changes in the underlying technology platform.

As a future work, a comparison of usefulness and reusability degree between our proposed mechanism (WSDMDA) and OOHDMDA [29] will be conducted based on some criterion which are displayed in table I.

TABLE I.         COMPARISON BETWEEN WSDMDA AND OOHDMDA

| Criteria | OOHDMDA | WSDMDA |
|---|---|---|
| Base Method | OOHDM | WSDM |
| PIM | Redesigns the object model of OOHDM to use as PIM after adding Behavioral Semantics Model | Redesigns the conceptual model of WSDM to use as PIM after adding user – interest profile |
| PSM | Targeted to servlet-based platform. | Generic PSM |
| Model Transformation | Navigational Transformation & Conceptual Transformation | Redesigned Conceptual Model (PIM) to Generic PSM |

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