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# Diraya Project. The power of metamodels in real experiences with Web Engineering

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## Abstract

The number of approaches for Web environments has grown very fast in the last years: HDM (Hypermedia Design Model), OOHDM (Object Oriented Hypermedia Design Method) or WSDM (Web Site Design Method) were the first ones and, now a high number can be found in the bibliography. With the definition of MDA (Model Driven Architecture) and the acceptance of MDE (Model Driven Engineering) techniques in this environment, some groups are working in the use of metamodels and transformations to make their approaches more powerful. UWE (UML Based Web Engineering) or OOWS (Object Oriented Web Solutions) are only son examples. However, there are few real experiences with Web Engineering in the enterprise environment and, really, very few real applications of metamodels and MDE techniques. In this paper presents the practical experience of a Web Engineering approach, NDT (Navigational Development Techniques), in a big project developed in Andalusia is presented. Besides, it shows how metamodels can be very useful to work in real environments.

*Keywords: Health management, information systems, web methodologies*

## Resumen

El número de propuestas metodológicas para entornos web ha crecido rápidamente en los últimos años: (Hypermedia Design Model), OOHDM (Object Oriented Hypermedia Design Method) or WSDM (Web Site Design Method) fueron los prmeros, pero actualmente hay un mayor número de propuestas disponibles.

Con la definición de MDA (Model Driven Engineering)y la aceptación de la Ingeniería Guiada por Modelos (MDE) en este entorno, algunos grupo están trabajando en el uso de metamodelos y transformaciones para hacer sus propuestas más potentes. UWE (UML Based Web Engineering) o OOWS (Object Oriented Web Solutions) son solo algunos ejemplos. Sin embargo, hay pocas experiencias reales en estos entornos y, realmente muy pocas aplicaciones de MDE en el mundo empresarial. Este artículo presenta la experiencia práctica de la aplicación de la propuesta NDT (Navigational Development Techniques) en un gran proyecto desarrollado en Andalucía. Además, demuestra cómo los metamodelos pueden ser muy útiles para trabajar en ambientes reales.

*Palabras clave: Gestión de Salud, Sistemas de Información, metodologías web*

## 1. Introducción

In the last years, Web Engineering[0] has been studied by several important research groups. With the fist approach for Hypermedia Systems, HDM[0], research groups started to propose, develop and analyse different techniques, models and procedures in order to offer a suitable methodological environment for the new Software Engineering area.

As a recent tendency, several groups are basing their approaches on the Model Driven Engineering (MDE) [0] and in the paradigm defined by the OMG with MDA (Model Driven Architecture) [0]. Recent literatures offer suitable examples of MDE applications in the Web Engineering. They analyses their advantages and their powerful possibilities. However, they do not use real applications of these approaches.

Previous comparative studies [0][0][0] demonstrate that Web Engineering is being hardly studied by the research community, but all of them conclude that there are not applied enough on the enterprise environment. With MDE, the same is happening.

This paper presents a real experience with Web Engineering and Model Driven Engineering. It starts analysing the situation of MDE in the Web Engineering environment and it analyses briefly its advantages and consequences. In section 3, NDT (Navigational Development Techniques) is presented. NDT is a Web Engineering approach based on MDE, that has been used in different real project in Spain.

Although NDT is being applied in several real projects, Diraya project was selected for this paper. This a very ambitious project to manage health information in any hospital in Andalusia. In section 4, a global vision of Diraya is presented.

Section 5, shows the real advantages of using MDE and Web Engineering in a project like Diraya. It analyses how metamodels can offer a powerful environment to fuse approaches, standards or, even, to use different tools based on metamodels.

Finally, conclusions and future works are presented.

## 2. Related Works

Nowadays, MDE and MDA are very often applied. In the Web Engineering environment is not different. This paper is mainly focused on the requirements phase, for this reason, we are going to focus on approaches based on metamodels and MDE for Web requirements. However, its necessary to stick out that every day, more Web Engineering research groups are working in MDE environment.

One of the most recent works is [0]. In this paper, a transformation approach to produce Web application prototypes from a Web requirements model is presented. They proposed a requirements treatment based on the task metaphor. Valderas et al. offer an extension of this approach to deal with the specific characteristics of Web requirements. After that, they present a way to derive navigational model of OOWS[0]. Firstly, they propose to define requirements like tasks, these tasks are translated into a AGG Graph. Using Graphs transformations, the analysis models are obtained. The approach is supported with a tool that is available. This work is very interesting because they offer a suitable solution for transformation supported by a tool. However, its transformations are not based in OMG tendencies. This provokes that they are not compatible with other similar approaches.

In [0] the power of metamodel to make compatible approaches is presented. In comparative studies about Web approaches, a general conclusion is that similar concepts are used or represented with a different number of models, techniques or artefacts. Thus, for instance, navigational classes are presented with different elements in UWE [0], OOHDM[0] or WebML[0]. Escalona and Koch show in this paper how metamodel can represent concept independently of its representation or notation, only concepts are important. They present a metamodel for Web requirements, named WebReq, that represents requirements model of W2000[0], NDT, OOHDM and UWE. In [0], they continues their works using QVT[0] to get analysis models from this metamodel. These works are interesting because they are completely based on UML[**¡Error! No se encuentra el origen de la referencia.**] and QVT,

standards defined by OMG. However, they are too theoretical and it must support with any tool to make transformations automatic.

Fernández and Mozón [0] present the possibilities of working with metamodels with tools. Thus, they present how a requirements metamodel can be easily defined in IRqA (Integral Requisite Analyzer)[0]. IRqA is a comercial tool that let define metamodels for requirements. In this sense, this paper presents the power of tools that support metamodels because they are suitable for any approach defined using metamodels. This work is, in fact, very practical but it is not an approach for Web. They not offer specifical artefacts to deal with Web environment and they just offer an approach for classical requirements treatment.

## 3. NDT (Navigational Development Techniques)

NDT is a methodological approach to deal with requirements in Web Environments. NDT was proposed in order to support the requirements engineering and the analysis phase of Web Systems and it is based on the Model Driven Engineering.

Several comparative studies have proved that one of the less treated phases in Web Engineering is the requirements phase[0][0]. Most of approaches in Web Engineering are focussed on the analysis and design phases. They usually propose to use classical requirements techniques, like use cases, in order to capture and define requirements in Web.

Although use cases is a suitable technique to deal with requirements and they are easily understand by the user, sometimes they are very ambiguous [0][0]. For this reason, in the last year, several research groups are working in specific requirements treatment for the Web environment. For instance, OOHDM has proposed the UID (User Interaction Diagrams)[0], a specific diagram to deal with interaction requirements.

Another conclusion from comparatives studies it that, in Web Engineering, different aspects of software are treated in a separate way. This idea is followed in the analysis and design phases for several approaches. OOHDM, UWE, WebML or OOH[0] where conceptual, navigational, interaction, etc. aspects are modelled with different models are only some examples. This idea of concept separation can be moved to the requirements phase in order to get the advantages of concept separation. Thus, UWE deals separately with information requirements, functional requirements, etc. Or, for instance, W2000 defines different use cases for functional and navigational requirements.

Another important fact detected by the comparative studies is that, sometimes, requirements are defined in a very ambiguous way and it is very difficult for the analysis to translate the knowledge from the requirements definition to the analysis models.

With these ideas, NDT was proposed. Thus, it proposes a MDE approach in order to offer a suitable environment to capture, define, analyse and validate Web requirements.

The life cycle of NDT starts with the requirements engineering. Its artefacts are described with a metamodel for requirements that extends the metamodel of UML and follows the structure of WebReq[0] metamodel. In figure 1 the metamodel of NDT is presented. This metamodel can be define using a UML profile, which is also presented in figure 1.

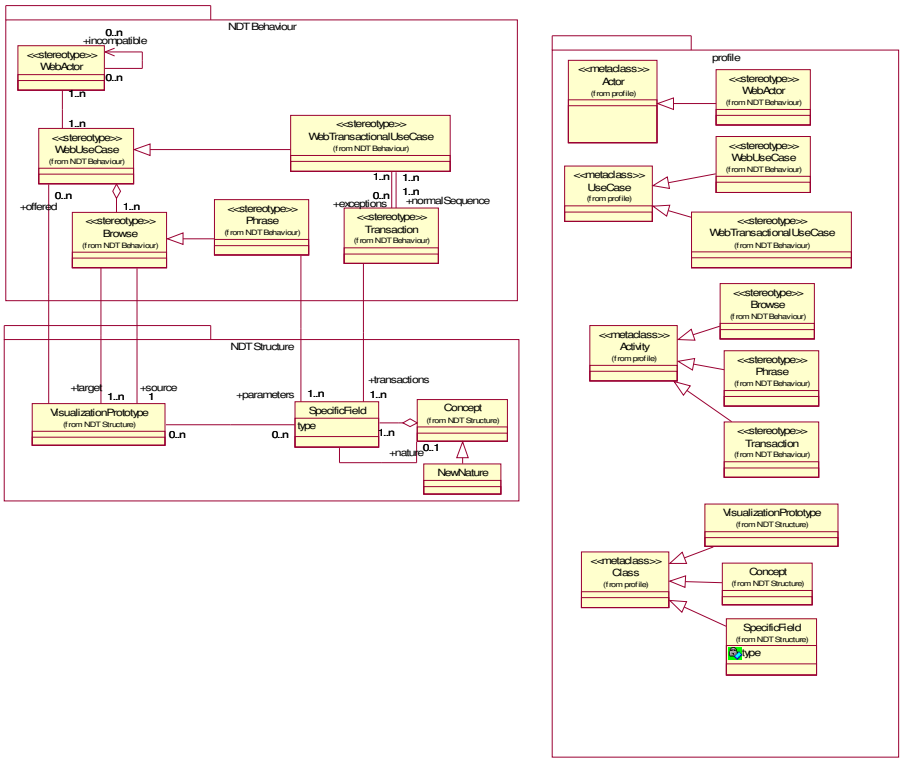


Figure 1. NDT Requirements Metamodel

In the requirements level, NDT divides requirements into four different kinds, which are all presented on the metamodel:

- storage information requirements, represented by Concept, NewNature and SpecificField metaclasses. They capture the information that the system has to manage.
- actors' requirements, represented by the WebActor metaclass. A web system can change depending of the user who interact with.
- functional requirements, represented by WebTransactionalUseCase and Transaction metaclasses. They capture information about the functionality that the system has to offer.
- interaction requirements represented by VisualizationPrototype, Phrases and Browse metaclasses. They compile the structure of the interaction with the system.

Thus, NDT follows the idea of concept separation. Each of these artefacts is treated with a specific technique. In order to describe each kind of requirements, NDT proposes the use of patterns. A pattern is a table with specific fields for each kind of requirements. This pattern is a practical vision of the metamodel concept. For instances, in table 1 the specific pattern to describe an actor is presented. This pattern was gotten for our practical experience in Diraya project. Although they are not presented in the metamodel, each row in the pattern is an attribute of the WebActor metaclass in the metamodel. Thus, patterns are really an easy interface to present the metamodel to the development team.

| | |
|---|---|
| **ACT-01** | Health expert |
| **Associated Objetives** | OBJ-01. Manage information about specialists that work with Diraya |
| **Description** | This actor represents any person that interact with Diraya system. It represents doctors, nurses, janitor, etc. |
| **Coments** | This actor assume the functionality common for any actor in Diraya. |

Table 1. An example of NDT patterns

Following the MDA notation, the requirements level of NDT represent the CIM (Computation Independent Model) level of this MDA approach.

The life cycle of NDT continues with the analysis phase. However, in this phase, NDT does not propose any analysis metamodel. As it was concluded in several comparative studies, there are too much analysis approaches for Web Engineering [0][0]. For this reason, NDT use the UWE analysis metamodel[0]. The selection of UWE is because UWE is completely based on UML and also, UML profiles are defined for.

UWE analysis models represent the PIM level of NDT. Between the CIM and the PIM metamodel, NDT defines a set of relations and transformation using QVT.

Thus, NDT solves some problems detected by other research groups.

It offers specific techniques for each kind of Web requirements.

It proposes the use of a MDD environment in order to make easier the translation between requirements and analysis.

It proposes the use of patterns to deal with requirements. Patterns are very easy to be understood by the user but, they also represent metamodel artefact in a structured way very useful for the development team.

It follows the separation concept paradigm proposed by several research groups for the design and the analysis phase. Thus, it can assume the advantage of this paradigm.

Besides, NDT is not only a theoretical approach. I has been applied in several real projects[0]. Nowadays, it was assumed by several public organisms like Consejería de Cultura[0] or Servicio Andaluz de Salud[0], as a requirements methodology for their software projects. Also, some private companies are using them. Thus, everis and Telvent are using it in several projects.

## 4. Diraya Project

Diraya Project is a very ambitious project developed by the Servicio Andaluz de Salud (SAS). SAS is the public government in Andalusia that manages hospitals, health centre or any health public system.

Some years ago, Diraya project started to manage the primary health attendance in Andalusia. It was called Primary Diraya. However, now, It is being extended to the specialized health attendance. It is Specialized Diraya.

Specialized Diraya is a Web system to manage all the information about patients that visit any hospital in Andalusia. Independently, if they visit the hospital for a concerted visit or an urgency visit.

Specialized Diraya will be implanted in 29 hospitals in Andalusia and It will be used by more than 62000 final users composed by doctors, nurse, etc. The complete health information in hospital in Andalusia will be managed by Specialized Diraya.

The project started some months ago and it is being developed by six big software companies in Andalusia: Telvent, Indra, everis, Tecnova, Accenture and Isoft. They are working together in order to get the best results. They are experts in health systems and they are mixing their previous knowledge during the development process.

Specialized Diraya development was divided into two phases. The first one will be presented in June 2007 and it will be implanted in one hospital in order to value it. Nowadays, the analysis phase has just finished.

Although Specialized Diraya development is based on Métrica [0], a methodology proposed by the Spanish government to public software projects. Métrica and NDT are compatible, thus, NDT was the environment used by the requirements and the analysis phase.

The group of analysts is composed by 13 people from the different companies and they are working together in order to get a consistent product. The complete group of the development team, including people from companies, analysts, designers, software experts in SAS, etc. is over than 40 people.

The magnitude of Diraya is a very interesting example. The high number of final users, analysts, designers, etc., the high number of requirements and the high number of different roles in the development is a complex and a real example that offers an important feedback for our research results.

## 5. The practical experience

During six months approximately, the group of analysis of Specialized Diraya was working in the requirements and the analysis phase. In order to use NDT as a methodological environment for these phases, the group had to decide several aspects.

The first one was the division of the system into different modules. Thus, six modules interconnect between them were define. Each company developed one of them.

### 5.1 The power of metamodels for tools

Another important decision in the project was the tool. With more than 13 people working in the analysis phase and a high number of requirements, a tool must be used. At the beginning, the first election was NDT-Tool[0]. NDT-Tool is a tool developed with NDT that covers the complete life cycle of NDT. It was developed by the University of Seville and it is free. The first version of NDT-Tool was developed in Visual Basic. Nowadays, a new version developed in J2EE is being developed in collaboration with everis and Telvent. When it was tested by Diraya group, the old version was not suitable for a group of analysts that are working in different offices and at the same time. The option of the new version in J2EE via internet was a good election but it was too young for the project.

For this reason, SAS and the University of Seville were working in order to find a suitable tool for Specialized Diraya. After looking for and comparing different possibilities, Enterprise Architecture [0] was the selection

Enterprise Architecture supports UML and it offers the possibility of extends the initial definition of UML with its extension mechanisms. NDT requirements metamodel and also UWE analysis model are define with an UML profile. For this reason, it was very easy to adapt the tool for the group. With Enterprise Architecture profile option, the profile of NDT was defined and companies used them to define requirements and analysis artefacts.

In figure 1 the interface of Enterprise used in Diraya is presented.

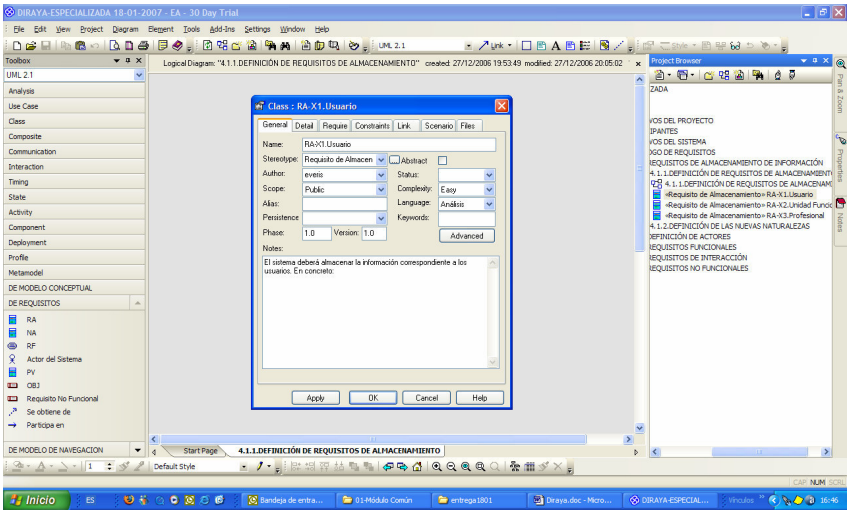


Figure 2- Enterprise Architecture interface for Diraya

On the left, different profiles for NDT phases are define (requirements, conceptual model and navigational model). In the right an index for NDT results in each phase is presented.

With this environment, companies can work with the NDT metamodel without any special knowledge about metamodels. Besides, Enterprise Architecture offers a tool to define transformation between models using MDA and, nowadays, we are trying to implement NDT transformation in order to get the derivation of CIM to PIM model automatically.

However, the power of metamodel for using tools lets offer a bigger number of tool for using an approach. In our approach another possibilities were offered to the companies.

Thus, for the second phase of Diraya, a double use of tool is being adapting. IRqA is a tool special for requirements treatment. It is also based on UML and It offers the possibility of defining metamodels and UML profiles. IRqA offers a better interface for users. Although the phase of requirements will be dealt with IRqA, the rest of the life cycle, even the analysis, will be treated with Enterprise Architecture.

Nowadays, we are working in the generation from IRqA models to the Enterprise Architecture models using the QVT relations of NDT.

Thus, thank of the definition of metamodel, Diraya users has tree possibilities: NDT-Tool, Enterprise Architecture and the fusion between IRqA and Enterprise Archiecture.

In conclusion, if an approach works with UML profiles, its artefacts can be easily defined in tools that work with UML and offer its extensions possibilities. Nowadays, other tools are being adapted to NDT. The idea is offering a different number of possibilities. Thus, they could select the best for their companies and their environment.

### 5.2 The power of metamodels for fussing approaches

Another important lesson learned is the power of metamodel for fussing approaches. NDT is a methodology that works only in the requirements phase and the analysis. When NDT was proposed, we notice the importance of make it compatible with other works and approaches. As it was pretende, comparative studies conclude that there are too much models and

techniques to deal with the same concepts in Web Engineering. For this reason, NDT uses UWE metamodels for analysis.

However, although metamodel can be very useful to make compatible different software engineering approaches, in Diraya project we detected that they are also very useful in order to fuse approaches of different environments.

In medical environments, a standard, named HL7[0] was defined in order to get a standard communication system in medical software system. In Diraya project an important requirements was to follow this standard.

Fortunately, HL7 is defined using also a set of metamodel. It offers a metamodel for use case and interaction metamodel, information model, message design and datatype and vocabulary. HL7 metamodel must be used in the design phase and it is necessary to translate user requirements into its metamodel artefacts.

In order to make the use of NDT useful for SAS requirements, we studied HL7 and NDT metamodels. Thus, some correspondences between analysis and design concepts were define.

### 5.3 The advantages of MDE

Although in the first phase of Diraya a practical tool to translate requirements into analysis models was not offered, because the time of this phase was to hard and tools can be not prepared, MDE was applied.

As it was presented, NDT transformations are defined with QVT. In NDT-Tool, these transformations were translated into Java algorithms. Thus, the step from requirements to analysis is automatic. These algorithms were offered to analysts and they applied them manually. Although this process is not the most orthodox, in the enterprise environment the time of development is one of the most important elements and they could not wait for the preparation of Enterprise Architecture.

Obviously, for analysts, the manual application of MDE was not easy but the result was very important for the project. The capture and definition of requirements in Diraya takes more than three months. During this phase, the results were:

- More than 200 storage information requirements
- 67 actors defined
- More than 250 functional requirements
- More than 210 interaction requirements

Despite of this high numbers and the manual application of MDE transformation, the generation of the analysis models just take one week.

This important reduction of time was an important advantage detected and stuck out by the companies and SAS.

Besides, during the MDE generation, the consistence between requirements definition and analysis model is assured. MDE keeps the consistence between models and it assures that requirements and analysis models represent the same. Thus, it was very interesting the high number of fails and mistakes detected during the transformations. When analysts generated the analysis models from the requirements, they detected that, sometimes, the analysis model that they had in mind was not the same than the model represented by their requirements definition.

The keeping of consistence that MDE offers let stop the snow ball effects. At the beginning of the life cycle, the correction of mistakes is simple but in each posterior phase, the correction is more expensive. The cost of changes grows like a snow ball. Thus, the correction of the requirements definition in Diraya just takes three days. However, it would be more expensive if they would be detected in a posterior phase, for instance, in the implementation phase.

## 6. Conclusions and future works

The high advance in the Web Engineering research and approaches presented in the last years offer suitable environments to work in Web development for companies and real projects. The advantages included with the application of MDE have improved these environments.

However, these environments are not really apply in practical experience. In Web Engineering, and in Model Driven Web Engineering, there is an important gap between theory and practise.

In the literature, papers that present the advantages of applying Web Engineering in Web projects, the reduction of time of MDE, the consistence between model when MDE is used, the power of metamodels, etc. However, very few practical experiences in real projects, with real development teams are presented.

This paper offers a different vision of Web Engineering. It shows a practical experience with Web Engineering in a real project. The paper has presented NDT, a methodological approach to deal with requirements in web systems based on MDE, and a big project developed in Andalusia, Specialized Diraya.

It has offered a practical and a real vision about the application of NDT to Diraya. It has presented how metamodel are optimal to fuse approaches and offer a group of suitable tools for the development team.

Besides, it presented how MDE can reduce the time of development and detect inconsistence and mistake in early phases, although in this case MDE was applied manually.

Obviously, tools offered by Diraya are not the best. As it was presented, we are looking for implementing QVT transformations in order to offer the possibility of automatic generation. In Enterprise Architecture, a language for MDA applications is offering but it is not based on QVT and it is not documented enough, so we are finding a lot of problems.

In any case, we think that is very important to count with practical approaches like the presented one. They offer an important feedback for research results. For us, the most important learned lessons were:

- Metamodels are a powerful tool for methodological environment. However, development team has not usually expert in metamodels. For this reason, it is necessary to offer a suitable interface to work with these metamodels. In the case of NDT, it proposes to use patterns. They result very useful to work with the team and also with the final users.
- Metamodels are powerful but the must be compatible. For instance, for the fusion between NDT and HL7, if they both are defined using a UML profile, it would be easier to detect the common artefacts.
- MDE and Web Engineering are necessary because Web systems have special characteristics that must be treated in a special way. However, they are useless in the enterprise environment if they are not support by a tool. For companies, the development team is an important variable and if they has to spend a lot of time in

documentation, modelling or transformations, they will never use research approaches.

Commercial tools are supporting the definition of metamodels and profiles. However, they are starting to work with MDE transformations. The research community needs powerful tools to implement transformations. For this reason, one of our future works is researching in tools that have offering this possibilities, like SmartQVT[0] or Moment[0] and measure if they are useful for the enterprise environment.

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