A PRACTICAL EXPERIENCE WITH NDT

The System to Measure the Grade of Handicap

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Abstract: The necessity of applying technological advances in the medicine environment is an unquestionable fact. In the last years, important applications of new technologies in medical systems to help doctors or to make easier the evaluation, the treatment or, even, the relation between the doctor and the patient have been presented. However, there is sometimes an important gap in the development of these new systems. The specific and complex features of the medical environment often complicate the communication between doctors, when they require a new system, and experts in computer science. This work introduces a methodological proposal to specify and analyze software systems. Its main goal is to make easier the communication between final users and customers and the development team. The report presents our own practical experience by the application of this methodology in a real system to measure the grade of handicap in patients following laws in Spain.

1 INTRODUCTION

The application of Computer Science and technological advances in any area is always a step forward in the evolution of this area. In the medical environment, this evolution is really important because it is oriented to improve the treatment of the patient.

However, when systems are very complex or specific in their vocabulary, in its requirements or even in its objectives, the communication between experts in Computer Science and experts in the system makes the project very difficult and expensive (Sommerville, 2002) (Pressman, 2002). Most systems developed in the medicine environment present this problem.

In the department of Computer Languages and Systems of the University of Seville, a new methodology named NDT (Navigational Development Techniques)(Escalona, 2004) has been developed. This methodology works in the first phases of the life cycle of a software project: requirements and analysis, and its main objective is to make easier the communication between users, customers and the development team.

NDT has been applied in several real environments and several real projects that are being used nowadays(Escalona, 2004). However, a medical project was a great opportunity to validate our methodology. In this work, we present an abstract about the application of NDT in the development of a system to measure the grade of handicap following Spanish laws.

The report starts, in section 2, with a description of the problem to solve in the project. In section 3, a global vision of NDT is presented and section 4 reports the final obtained system and the application of NDT in its development. Finally, in section 5, conclusions, future works and final evaluation are presented.

2 THE PROBLEM TO SOLVE

In the Royal Decree 1971/1999 (23/12) the Ministry of Social Issues in Spain defined how to evaluate the grade of handicap of a patient in order to get a level of handicap. This level of handicap is essential for an patient because, depending on this grade, he/she gets subsidies, helps or special cares in Spain.

However, the application of this Royal Decree is not easy. To grade the handicap grade of a patient, doctors not only have to assess the handicap itself, but also its consequences for the patient. For instance, a patient who cannot walk can also have psychological problems as a result of his/her physical problem.

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In this sense, the Alcer Foundation (Alcer, 2005) suggested to the Madeira group, at the University of Seville, to develop a system that facilitates the handicap grading process for doctors and patients. In September 2003, Madeira group and Alcer Foundation started to develop a new web system.

The development of this system was not easy for several reasons:

The system was very new. There was no previous experience in that, so the development environment was very difficult for the development team.

The terminology of the system was very complex and close to the medical environment. This was a problem for the computer science ones because they did not have specific formation in this area.

For all these reasons, the working environment could be defined as a very complex one for the team. Techniques to specify, analyse or design the system must be suitable for users and customers and also for the development team.

3 INTRODUCING NDT

NDT is a methodological proposal to specify and analyse requirements in web systems. This proposal is focused on two main aspects (Escalona et al., 2003)(Escalona et al., 2004)

The first one is that web systems have special and critical characteristics. It is why in web development, these special characteristics have to be dealt with special methods and techniques suitable for them (Barry & Lang, 2001) (Retschitzegger & Schwinger, 2000) (Escalona & Koch, 2004).

The second point is that in web system, it is usually necessary a good communication between final clients, the experts in the system subject and the development team because only the users know how the system must be.

NDT is a methodological process in the web environment that it is focused on the requirements and analysis phases. It offers a systematic way to deal with the special characteristic of the web environment. NDT is based on the definition of formal metamodels, presented in (Escalona, 2004), that allow to create derivation relations between models. NDT takes this theoretic base and enriches it with the necessary elements to define a methodology: techniques, models, methodological steps, etc. in order to offer a suitable context to be applied in real projects.

In this sense, NDT starts with the theoretic definition of the requirements engineering metamodels and proposes a methodological environment to drive the team in the capture, definition and validation of requirements following the next ideas:

1- In the elicitation of requirements NDT assumes its own techniques inherited from the requirements engineering environment like interviews, brainstorming or the study of the previous systems (Duran, 2000).

2- In order to describe requirements, NDT uses some standard models, like the use cases, and patterns. A pattern is a special template with predefined fields that must to be completed between the development team and final users (Escalona, 2004).

3- In the validation of requirements, NDT also proposes a group of techniques like the traceability matrix (Duran, 2000) or the fuzzy thesaurus (Mirbel, 1995) adapted to NDT patterns in order to propose a more agile requirements validation (Escalona & Cavarero, 2005).

NDT also normalizes the structure of the results that must be developed during the requirements engineering and it proposes which are the complete structure of the document.

With the theoretic base of metamodels and relations, the next phase is the analysis one. In the analysis phase three models are generated:

1- The conceptual model, that defines the static structure of the information and its relations.

2- The navigational model, that defines how users can navigate through the information.

3- The abstract interface model is composed by a group of HTML and XML prototypes that let validate the conceptual and navigational models.

However, the generation of these three models is made in two phases. In the first one, analysis models are generated systematically from the requirements using the theoretic relations defined between models. In this sense, NDT can be defined as a model driven proposal. These models are named basic analysis models.

In these basic models, analysts can make some changes in order to make more suitable these models, getting the final analysis models. The construction of these final models is not systematic and they depend on the experience of the analyst. NDT offers some guides and processes in order to make easier the analyst's revision.

Besides, NDT controls that the changes proposed by the analyst are agree with the definition of requirements. In this sense, NDT manages that the final analyst models and the requirements definition

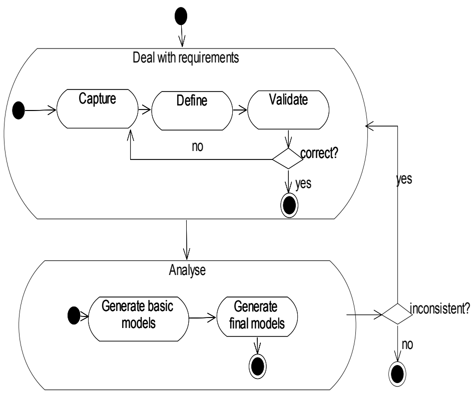

Figure 1: NDT Development Process.

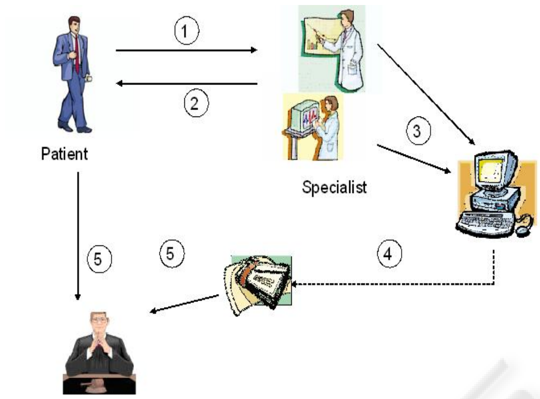

Figure 2: Schema of the system behaviour.

are consistence. In figure 1, the NDT life cycle is presented with an activity diagram.

Final models generated in NDT are compatible with other proposals like UWE (Koch, 2001) or OOHDM (Rossi, 1996). For this reason, from them, the development team can continue the life cycle with these other proposals that have been widely accepted by the research community.

In conclusion, NDT can be define as a methodology to the requirements and analysis phases, the rest of the life cycle is dealt with other important proposals, thus it is not necessary to work more on them, like it is shown in the comparatives studies. NDT is offered to cover a gap in the treatment of the life phases in the Web Engineering (Desphande et al., 2002).

Finally, it is important to stick out that NDT has an associated tool, named NDT-Tool (Escalona et al., 2003) that supports all the life cycle of NDT. This tool lets automate all the systematic processes of NDT, apply all its techniques and get the results automatically.

4 THE FINAL SYSTEM

The development of the system to measure the grade of handicap was an mportant test for NDT. The development environment was very difficult: the law was very new, there was no any previous system to apply it, the terminology of the users (medicine, illness, etc) was really difficult for the development team, etc. In conclusion, a great real experience to prove if NDT really ensures communications with the user.

The essential idea of the system is shown in figure 2.

The handicapped patient, once finished the treatment and following the indications of his/her family doctor, visits various specialists who has to value his different health problems (physical and/or psychological) derived from his illness. This communication is represented in figure 2, steps 1 and 2. Specialist can advise the visit to another specialist who values another aspect of his/her handicap. Each specialist completes his/her own evaluation. Each partial evaluation is stored in the system, which is offered through Internet. This is represented in figure 2, in step 3.

When the process of evaluation is finished the final evaluation report is automatically generated by the system. It can be generated by the patient's family doctor or by any specialist. This final report, which is structured following the Royal Decree rules, is presented by the user to the Spanish Government who defines the grade of handicap and calculates the compensations, payments or subsidies for the patient.

The interface was an important aspect of the system. The law covers various systems, physical aspects so as psychical, and includes a great complexity. Each specialist only must access to the matter that is called on to him/her to evaluate, but, also, he/she must be able to access to consult other evaluations made by other specialists of an agile way.

In order to present all the information, the system is structured like a tree. Each leaf of the tree represents the possible damage of a subsystem of the patient: the skeleton-muscular system, the nervous system, etc. In figure 3 an example of the digestive system is presented (The system is developed in Spanish, for that reason the screen is in Spanish).

In each lead, the specialist found each piece of information that have to be valued for each patient according to the Royal Decree. The tree is always on the left side and, when a concrete lead is selected all the information about this concept is presented on the right side.

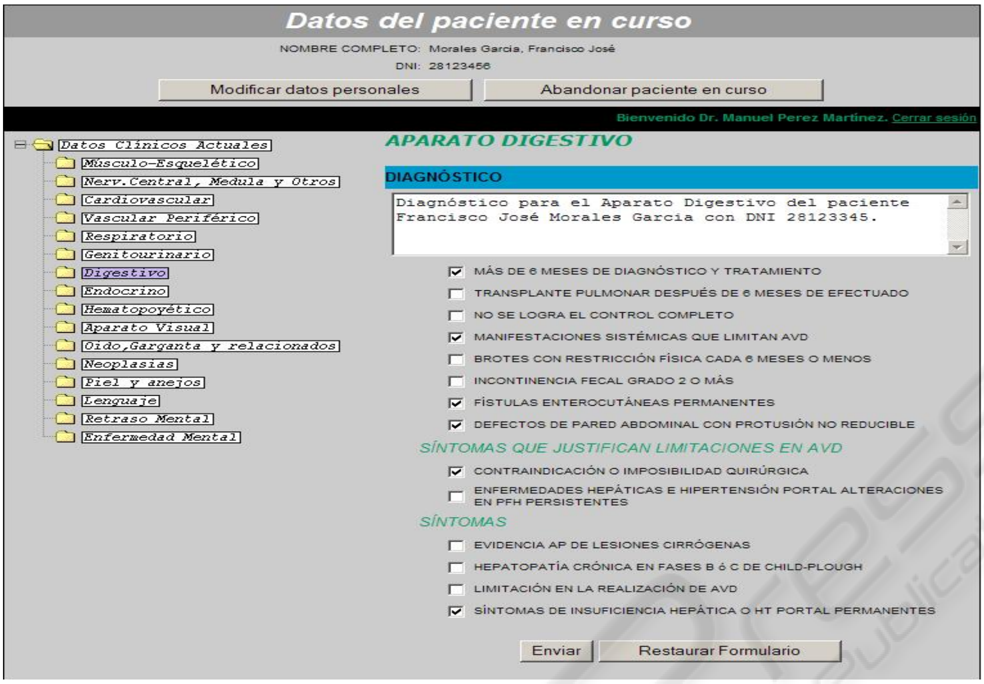

Figure 3: A screen of the system.

This form of interaction with system is very comfortable and intuitive for the doctor. The tree displays all the information covered by the law but in a structured way according to the different body systems. All the details and casuistries indicated in the law, as well as the restrictions to follow by the doctors are controlled by the system, not allowing inconstancies or errors. In addition, as the tree appears as the Windows Explorer turns out very intuitive to use by the doctors.

The final result has had a great acceptance, but it would not have been possible to arrive at it without a methodological initial study of the system. In this point, the NDT use has been fundamental. NDT patterns have been a great technique of communication that has made more fluid the enclosed work between the users and the development team.

Once the objectives were defined, the information storage requirements or, what is the same, the information that had to cover the system according to the law, began to be defined. These data were presented in patterns similar to the one presented in table 1.

Specific data describe each concrete piece of information that must be stored for each patient. For each piece of specific data its name, a short description about its meaning and its nature that describes the structure of this piece must be defined. There are some classical natures like string or integer, but there are also some advanced natures. For instance, in the field “actual treatment” the nature is RA-02. This means that the structure of this piece of data is described by requirements RA-02, another storage requirement, which is also defined in the system.

When the group of storage requirements was defined, the next step was to set up the different roles of users that could interact with the system. In this point, only two actors were defined: the doctor and the administrator. The first one could only manage users’ information. When a new doctor wants to use the system, he/she has to ask for permission to the administration. The second one, the doctor, could access to any information of the system. Nevertheless, it was important to find some structured form to show all the information.

The next step was to study the functionality of the system. The system did not have a very complex functionality. Basically:

- To manage information about patient and his/her evaluation and treatment.
- To generate the final report following the restriction of the law.

The most critical aspect of the system was to establish a good navigational structure that allowed to access to the information in an easy way. In this point, the study of the interaction requirements was fundamental.

With the definition of the interaction requirements patterns, the development team and the users decided to structure the information in the different organic system presented in each lead of the tree shown in figure 2 (Muscle-Skeleton, nervous central, cardiovascular, peripheral-vascular, respiratory, digestive, and others).

In the last step, some other requirements like the necessity of security in the treatment of the information were defined.

The complete application of the NDT to this system, all patterns and diagrams can be found in (Villadiego et al., 2004). Nevertheless, observing the pattern of table 1 some conclusions can obviously be obtained.

Table 1: An example of pattern in NDT.

RA-01	Patient's information	
Description	This pattern describes what information must be stored for each patient in the system. Concretely:	
Specific Data	Name and description	Nature
	Name: It stores patient's name.	String
	DNI: It stores patient's number of identity national document..	Integer
	NSS: It stores patient's number of the Social Security.	Integer
	Born Data: It stores patient's born data.	Date
	Phone number: it stores patient's phone number.	Integer
	Weigh: It stores patient's weigh.	Integer
	Height: It stores patient's height.	Integer
	Actual treatment: It stores all the information about the actual treatment of the patient.	RA-02
	Specialists' evaluation: It stores all the information about the validation of the grade of handicap made by specialists.	RA-03

Although each pattern for each requirement is different and here it was only presented the storage information requirements one, everyone follows the same structure and all of them look for collecting the necessary information in the simplest way.

For that reason, the patterns are easy to understand by the end user, in this case the doctors. The terminology used in the fields and the descriptions has been completed according to the argot of the system.

But the patterns are also extremely useful for the development team that finds in them a structured definition of the requirements

This structured definition is very important in the following phases of the life cycle. In fact, NDT proposes systematic processes to go from the patterns to the analysis models.

In this system, with NDT-Tool, a conceptual class diagram, a navigational class diagram and the prototypes of the system were derived automatically from the set of patterns.

The automatic attainment of results trimmed the time of development and, therefore, the cost of the project. In addition, the prototypes resulted helpful to validate the results with the user.

While the definition of requirements was made with the user and validated by this one already from first phases of the life cycle, the rest of the process, design and implementation, was a pure task of the development team. This one was fundamentally based on the structured definition of requirements.

In general, although the work in the requirements engineering supposed a concerted effort for the team, it was compensated by the reduction in price and the quality of the results in the later phases.

5 CONCLUSIONS AND FUTURE WORKS

This paper presented a real and a practical experience with our methodology, NDT. This application has been very important in this project in several aspects. The first one is to value if NDT and its techniques and models were efficient to deal with complex development environment. We have got very good results in that. Patterns offer a good way of communication with the users and make easier the work between users and the development team.

By other way, the automatic generation of models in the analysis of NDT makes shorter the development time. To get automatically some prototypes of the system is a good technique to evaluate requirements with users. The disadvantage we have to stick out is that the maintenance of patterns can be sometimes very complex and expensive for the system. For this reason, we concluded that, mainly in complex projects, it is necessary the use of NDT-Tool to manage patterns.

As a contribution for the medical environment, the final system has resulted in a complete success. It is being used by a lot of specialist in Andalusia (in the south of Spain) and it is being adapted to be accepted in all the country.

As a future work we are thinking to apply some statistical and data mining techniques, obviously keeping the patient's anonymity. Thanks to these techniques, we hope to find relations between illnesses. For instance, to establish rules like "if a patient has lost his leg and he/she has not worked for several years, he/she will probably have some psychological problems".

It could be a good guide for the family doctor or specialists to get the most suitable and complete evaluation for the patient.

As final conclusion two ideas can be stuck out. The first one is the importance to keep a good communication between researchers in computer science and medicine. The computer science community has to validate its approach in real projects to sure the value of its results. Also, medicine community must incorporate, as much as it is possible, the technological advances in its works to obtain the best results. The second main idea is that the team work between these research areas can get good projects and results that help patients and their families and make easier the application of treatment, the granting of helps and, in general, the dealing of their health problems.

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