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CHALLENGES FOR THE ADOPTION OF MODEL-DRIVEN WEB ENGINEERING APPROACHES IN INDUSTRY

ESTEBAN ROBLES LUNA
Laboratorio de Investigación y Formación en Informática Avanzada (LIFIA), Universidad Nacional de La Plata, La Plata (Argentina)
esteban.robles@lifia.info.unlp.edu.ar

JUAN MIGUEL SÁNCHEZ BEGINES
Web Engineering and Early Testing Group (IWT2), University of Seville, Seville (Spain)
juan.sanchez@iwt2.org

MATÍAS RIVERO
Laboratorio de Investigación y Formación en Informática Avanzada (LIFIA), Universidad Nacional de La Plata, La Plata (Argentina)
mrivero@lifia.info.unlp.edu.ar

LETICIA MORALES
Web Engineering and Early Testing Group (IWT2), University of Seville, Seville (Spain)
leticia.morales@iwt2.org

J.G. ENRÍQUEZ
Computer Languages and Systems Department. University of Seville. Av. Reina Mercedes s/n, 41012, Seville, Seville.
jose.gonzalez@iwt2.org

GUSTAVO ROSSI
Laboratorio de Investigación y Formación en Informática Avanzada (LIFIA), Universidad Nacional de La Plata, La Plata (Argentina)
gustavo@lifia.info.unlp.edu.ar

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Model-Driven Web Engineering approaches have become an attractive research and technology solution for Web application development. However, for more than 20 years of development, the industry has not adopted them due to the mismatch between technical versus research requirements. In the context of this joint work between academia and industry, the authors survey hundreds of engineers from different companies of the world, and by statistical analysis present the current problems of these approaches in scale. Then a set of guidelines is provided to improve the model driven Web engineering approaches in order to make them viable industry solutions.

Key words: Model-Driven Web Engineering, Human-centred interfaces, MDE, Industry
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1 Introduction

Model-Driven Web Engineering (MDWE) approaches appeared 20 years ago to fulfill a missing area of Model Driven Development: Web application development [1]. From that moment, about 7 to 8 of MDWEs [2] have been created, but only a few of them have ended up providing tool support. However, only one has become the mayor player with small company and support from Object Management Group (OMG) to convert its language into a standard.

Although MDWEs approaches have claimed to improve multiple aspects of Web application development such as code quality, development speed and level of abstraction, we have formulated the following research question: why has the industry paid little attention to MDWEs?

A recent study [3] has presented the 20 obstacles that hinder Web application scalability, and though they are not specifically targeted to the applications derived from MDWEs approaches, they are still affected by these applications. Another study related to Web Engineering in the Cloud, clearly explains some of the problems of moving the current tools to support this kind of applications. It does not focus on why MDWEs approaches are not a viable solution in the industry, thus, some of the problems presented openly show related technical limitations of current MDWEs approaches.

In this study, we present a list of issues that make difficult the usage of MDWE approach in medium to big size companies and as a consequence, it shows particular practical problems that need to be solved to back up the claims that the MDWE community has made for years. To provide a context for the issues that have been found, Figure 1 presents an agile development lifecycle process of a Web application. In this figure, the main phases appear in bold type format and the issues that hinder the usage of MDWE approach are represented by post-its that are stuck to the picture in the affected phase in which the issue is located [4].

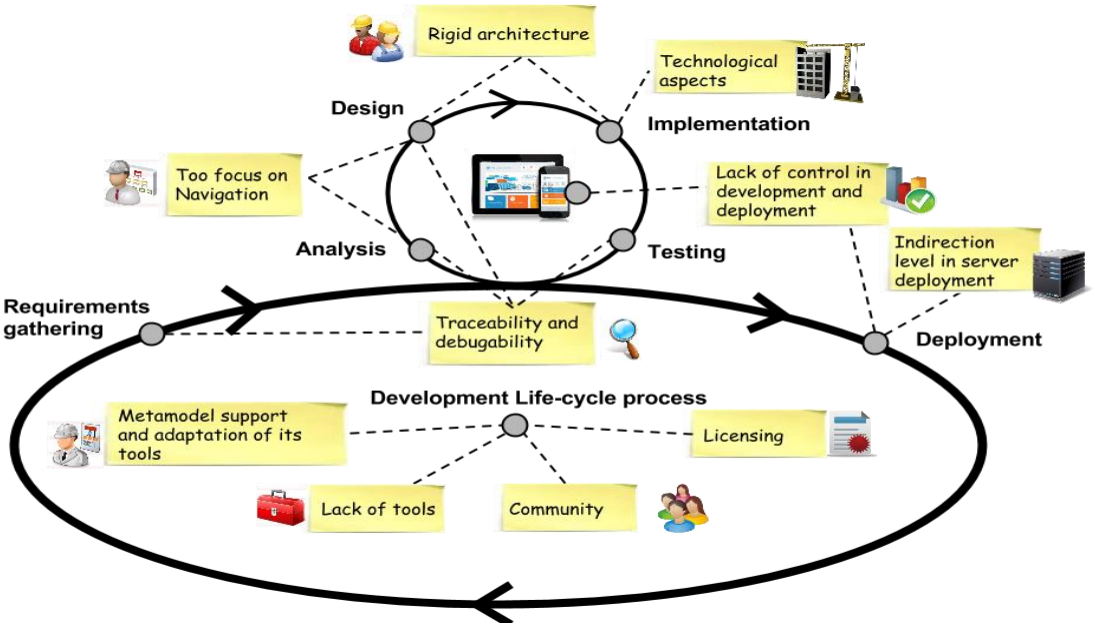

Figure 1 Issues that hinders the usage of the MDWE approach in medium to big size companies

The study uses small experiments to apply MDWE approach in a company, in addition to an exhaustive literature review to give support to its needs. As many different aspects are considered (not only technical) when dealing with limitations of MDWEs approaches, we have created a categorization to stress the area where the issue is found:

- Social [S]: A social issue is related to problems among people involved in the project or in the software artifact.
- Technical [T]: A technical issue is associated with the software elements that constitute the Web application.
- Economical [E]: An economical issue is linked to the project's budget or expenses involved in the development of the application.

Table 1 shows the addition of categorization of issues that we will be presented in the following subsections. The list of issues was abstracted from the interviews we conducted with the engineers and to the best of our efforts capture as many aspects as possible of a modern development process. With the same philosophy, it was decided to include not only technical aspects (as all MDWE take into account) but also social and economic ones. Modern Web engineering approaches in the Industry are affected for at least the 3 of them. Each subsection explains the concerns and offers a final guideline to solve them.

	Social	Technical	Economical
Lack of control in development and deployment	X	X	X
Too focused in navigation		X	
Metamodel support and adaptation of its tools	X	X	
Traceability and debugability		X	
Lack of tools		X	
Rigid architecture		X	
Technological aspects		X	
Community	X		X
Licensing			X

Table 1. List of issues by category

The experiment is based on a survey that evaluates both the characteristics of the companies participating in the project and the guide to solve the problems found. This survey tries to address all the issues from the Social, Technical and Economic point of view.

The aim of these surveys is to extract helpful information from these companies in order to validate or refute the hypotheses in some way. The results obtained will be considered reliable, since all the companies that have participated in this experiment are of a relevant size and reputation in the software world. Each of the companies has provided specialists in the field as project managers, analysts or senior programmers, who are familiar with the problem to tackle.

After the application of the experiment, we will state whether the hypotheses are valid, that is, if they solve the problem of each of the phases of Web development, or in contrast, it is necessary to reformulate a new solution guide. This can open the field of the MDWEs approaches to achieve a framework or standard that may cover the needs that companies demand from this methodology and this way, the industry will pay more attention to them.

In this paper, we will firstly talk about the MDWE approach and its problems to be applied. In section 2, we will present the related work to these problems. In section 3, we will describe the experimentation phase and in section 4 we will propose a series of challenges to solve some of the problems identified together with a survey. Next, data obtained in the survey will be analyzed and validated in sections 5 and 6, respectively. To end up, section 7 will state a set of conclusions and it will be presented future lines of work.

2 Related Work

Since the beginning of the 21st century, the software community has widely accepted languages of modeling for development of Web applications. The MDWE approach has tried to incorporate these languages into the lifecycle and address them in several stages.

From the onset of the MDWE approach, several solutions have emerged that have attempted to support different Web technologies (such as Rich Internet Application (RIA), Semantic Web or Mobile Web among others) and have tried to improve the coverage of the lifecycle of applications according to the specification of requirements, testing and maintenance [5].

Various solutions were proposed concerning the negative aspect of having a myriad of design approaches and annotations in the MDWE. The first one was to unify the different methods by drawing the best parts from each of them [7]. The second proposed to make all approaches interoperate in one way or another by allowing better portability among design models and facilitating their connections [8]. The feasibility of creating a standard was studied and finally, OMG adopted the IFML standard as a solution to this problem.

Another important aspect that the MDWE approach uncovered was to provide support tools and techniques that would play an important role in simplifying the design, development and evolution phases of applications. CASE tools play a key role for the software engineer to increase productivity, therefore, these tools are of great relevance when adopting the MDWE approach. This would have a great impact on the improvement of software industry that feeds on such tools [5].

The impact of MDWE approach in the industry has not been sufficiently studied although we can argue that the application of Model-Driven Software Engineering (MDSE) is widely adopted in various domains of industry and there is a large number of tools that have assimilated this paradigm.

MDSE based its development on specific domain models rather than on more general and standardized languages like UML [9,10]. There are many negative aspects found in companies when adopting MDSE as the effort in training on MDSE techniques. In addition, a tool does not always support this paradigm properly, as we will analyze later, among other aspects, such as immaturity, complexity and usability of these tools, which mean that the costs of applying MDSE have increased [11].

Another point of debate is the need to acquire proprietary software or otherwise create a large community that develops free tools to support the treated paradigm. Eclipse Modeling Tools suite is the premier open source technology for deploying MDE used by IBM and Oracle. There are other applications, like JetBrains Meta Programming System, that are proprietary technologies. In contrast, tools can be differentiated depending on the language of modeling where we find these tools. Thus, some of them may use the UML language and some others may use specific languages.

Finally, it is worth mentioning the effort made by the academic communities where such tools have been developed trying to support these paradigms such as NDT-Suite [12], QuEF [13] or WebRatio [14]. NDT-Suite, for instance, was submitted to a survey in different companies where it obtained quite satisfactory results in terms of functionality, usability and utility [15].

Another issue that we will address in the survey is the importance of having a broad community that supports and compiles information of interest for a better implementation of the MDWE paradigm. The MDWE community grew at a rapid pace thanks to the first Web Engineering workshop held at the World Wide Web (WWW) conference in 1998 that focused on web-based modeling techniques. This enhanced a greater understanding for the community of the problems involved in the development driven by Web application models, thus forming a large volume of quite extensive knowledge that was published later in different places. This laid an excellent basis in the MDWE paradigm for professional in the area [5].

All these issues will be addressed in this paper from the perspective of users in companies that will evaluate them according to their criteria, that is, the need to improve these and many other elements of the MDWE paradigm. A series of proposals related to the aforementioned arguments will be proposed and validated based on a survey carried out by users.

3 Experimentation

In order to evaluate the MDWE approach, we understand that it is important to know the points of view of different profiles related to the object of analysis. That is why we have conducted this study through a survey.

In Software Engineering (SE), surveys are one of the most widely used research methods to carry out empirical research studies. The SE research differs from other disciplines, particularly with respect to its objectives and themes. Objectives are often associated with improving the development process or exploring new techniques and methods. The subjects of such studies usually involve well-qualified professionals with clear opinions of their areas of interest [16].

Following this method, we have intended to collect and assess evidence of a sample of interest in the subject to be treated. Taking them as a basis, we would validate if the solutions provided coincide with the evaluations of the participants and, this way, they would corroborate our contribution to the MDWE paradigm.

The decision to apply this experimentation technique has been for the number of users participating in it and that, therefore, another more open method would have resulted in a long and expensive study. Thanks to this method and the possibility of doing it via Web, it has made us opt for this method and no other more complex and durable [17].

4 Challenges

4.1 Lack of control in development and deployment [S, T, E]

Creating a Web application is a complex process that involves not only coding/modeling, but also having meetings with stakeholders and debugging the application to fix production problems. In particular, when the application is deployed, aspects such as monitoring, logging and profiling become more important [3]. Therefore, the engineering teams that develop the Web application have the ownership and responsibility for the deliverables. As a consequence, they need to control the complete process (from development to deployment).

Despite the benefits that Model-Driven technologies offer, they also add an extra level of complexity as the derivation process is seen as a "magic wand" that obtains an application from a set of models. Most MDWE tools hide and make this process "close source" creating a dependency between the MDWE tool and the development teams. This dependency is not good with time constraints and not having the source code available to everyone makes things even worst. Additionally, it is highly probable that the commitment from the MDWE tool team requires paying fees in the form of licenses, what adds another economic cost to the development.

4.1.1 Guideline

MDWE tools need to provide the following aspects in order to deeply control the actual development:

- Ways to hook in the modeling and transformation phases, so that developers can add and improve the development process based on the application they are building. This could be done, if the transformation algorithm works using the template method design pattern.
- Make the code open source, so that the tool can be easy to debug by the development team in case problems arise during development or maintenance.

4.2 Too focused in navigation [T]

Original hypermedia-based Web applications that were developed 10 years ago are rather different from the current integration Web paradigm, where navigation is one tiny concern. Aspects such as Rich Internet applications, integration with different systems, search capabilities, personalization and recommendation have become more complex and relevant points than navigation itself.

In the early stages, MDWEs approaches were created to adapt the navigation paradigm from hypermedia to the Web. Many new concepts were introduced and although most of these enhancements have been reported in the literature [18], only a few of them have been actually implemented. As a consequence, today the main model of industry leading WebRatio is the navigational model that describes the navigational paths that a user can follow. On the contrary to what many researches have shown about the importance of UI aspects (e.g. integration) navigation is still the most important aspect for MDWE approaches.

4.2.1 Guideline

MDWEs approaches need to detach from being focused on navigation to support it as one concern of the Web application lifecycle. Furthermore, there is a special need to provide a real tool support for the features that MDWEs approaches claim to have and, in case that they are not supported, provide hooks to perform manual coding of these features.

4.3 Metamodel support and adaptation of its tools [T, S]

The increasing number of technologies that are being developed every day in addition to customer's time constraints poses multiple challenges to Web application development. Although these tasks can be performed manually (in code-based environments) and may be time consuming, they can be easily performed by extending and hooking into the hot spots that code-based frameworks provide.

In MDWEs approaches, this kind of extensions may be either carried out by instantiating some pre-existing metamodel classes or, if the functionality is not supported, by metamodel extensions. Extending a metamodel does not only require to add new classes and transformations, but also to adapt tools in a timely manner. Some approaches, such as NDT [19] or UWE [20], are extensions of the UML profile, thus, these approaches can be adapted more easily than others, such as IFML [21].

4.3.1 Guideline

Due to the existing technology and economic time constraints, metamodels and tools need to be adapted in a few days to cope with customers' demands. Currently, changing the metamodels and tools can take a few weeks and as a consequence cannot be accepted by the customer's timeline.

4.4 Traceability and debugability [T]

One of the most important aspects of software development is the ability to introspect, change and monitor the "live" application under development to quickly fix the problems; these actions are considered as "debugging" an application. Code-based development in order languages such as Smalltalk, Java and .NET have these features from the beginning making easy to iterate in the development process.

In MDWE tools where code is generated from models, the ability to debug is related to the derivation of traceability links between models and the generated code. Nowadays, only WebRatio partially supports this schema by allowing debugging the application under development [22]. Nonetheless, WebRatio needs further work to help trace back the problems while the application is running in production and exceptions occur as non-support is provided in this case. All these aspects make core engineers to avoid adopting MDWE tools as they lack control over the system under development.

4.4.1 Guideline

As high-level languages (e.g. Java) provide ways to trace back problems to concepts of the language (e.g. classes and line numbers in exception stack traces), MDWE approach should provide those features in order to detect the root causes of the problems. Additionally, further debug support must be provided to debug, evaluate and alter the application while it is running in a development environment.

4.5 Lack of tools [T]

Building a Web application requires a set of tools that eases the process of development, deployment and monitoring. For example, a typical JEE Web application can be developed using Maven [23] as a build system, Jenkins [24] for continuous integration and a variety of frameworks to actually build the application (Spring, Hibernate and JQuery, among others). To perform the actual deployment, a set of tools that automate and control the process from the moment the application is built to the instantiation of the servers and application deployment, and its initial monitoring is provided. All these tools, despite coming from a lower level of abstraction (if compare with the MDWE approach), clearly help build and deploy an application.

However, the actual development of the application from high-level models has been specifically pointed out in the MDWE area. Although this is correct from the MDWE philosophy, it increases the effort made in development and monitoring for many other topics discussed in this work (Technological features and Traceability, and debugability). Below, we provide concrete examples to the reader:

- There are no tools to trace stacktrace exceptions back to the model elements. This aspect makes very hard to correct errors of the application deployed.
- There are no tools to support the monitoring proves of the model elements and therefore, detecting performance issues is a hard task. By using New Relic [25], we can identify some of these points, but these would be classes derived from the MDWE tool that may correspond to multiple model elements.

4.5.1 Guideline

MDWEs approaches need to support a handful set of tools that help with the complete application lifecycle, in order to provide valid approach for industry. Some of tools mentioned in this section (Maven, Jenkins, New Relic) are fully extensible, so building some of these tools can be fairly simple by having good traceability links and extending them with the right information. Tools around the Web applications are one of the most critical aspects to keep the application running 24 for 7.

4.6 Rigid architecture [T]

Creating a Web application of any size may require small to big changes in a standard 3-tier Web application. Some aspects that need to be considered may involve integration with external services, processing queued information in an asynchronous manner, exposure of REST services for external users or internal mobile applications, among others issues. Hence, being able to adapt the architecture to support any of these types of requirements is extremely important.

In current MDWE tools, the architecture is not modeled at all and, as a consequence, they derive a simplistic 1-tier Web application [26]. 1-tier architecture can only handle a few sets of use cases and does not allow the development team to be able to adapt to future needs. A recent paper [27] has shown the need to model theses aspects in some way, so that they can be considered through the derivation process. In its actual state, MDWE tools can derive simple applications that may not scale properly, thus making harder to be adopted in medium to big size companies.

4.6.1 Guideline

To be able to adapt to more complex requirements that may involve functional (e.g. processing offline data) or non-functional (e.g. performance and scalability issues) requirements, the MDWE approach needs to model the architecture in such a way that development teams can decide which approach should be used. We must stress that although some architectures (e.g. 3-tier Web app) can be pre-configured, it is crucial to model the architecture primitives and let development teams abstract higher-level concepts from them, such as the 3-tier Web application, instead of hardcoding it.

4.7 Technological aspects [T]

Logging, caching, load balancing and profiling are some of the aspects that engineers need to build high-scalable Web applications [3]. The lack of any of them poses some limitations on the type of application that can be built. For instance, lacking a caching strategy forces the application to compute or fetch information for every request, thus limiting the application growth. Additionally, it may add the following problems:

- Run out of DB connections: Not being able to cache information stored in a DB requires the usage of a DB connection for every request. Thus, because of a DB limitation issue, the maximum number of users able to access the Web application is equal to the number of DB connections and as a result, new users will not be able to access the DB.
- Increasing response time: If we cannot store external service calls, those calls need to happen every time, thus increasing the overall response time of the requested Web page.
- Increase in hardware needed: If no cache is provided, we may need to use more hardware to re-compute values that were computed before.

Even though caching is a fairly simple aspect intrinsic to application development, MDWE approach consider it together with the aforementioned aspects, as "technological" element. Being part of this category means that little importance has being paid to model, thus engineers will have to tweak them in the generated code. As none of the MDWE tools provide a roundtrip between the generated code and models, these "technological" tweaks have to be adjusted every time the application is derived.

4.7.1 Guideline

The "technological" aspects need to be considered in some way inside the model-driven development. If the MDWE approach moves to consider and model them, it will provide a great benefit for the size and quality of the application that can be built with MDWE tools. At the same time, the response time can be reduced while a bigger amount of work is handled by the same amount of hardware, and that will clearly show the benefits of using a model-based solution.

4.8 Community [S, E]

In the MDWE research area, there is a good initiative like the MDWEnet [28], whose main research focus is meta-modeling and model transformations, and it was created with the aims of improving interoperability between existing MDWE approaches and their tools, so as to provide better methods and solutions to industry. Today, the fact is that most approaches have lots of disagree aspects [29]: Differences between meta-models and models, different way to implement transformations or different tools and used technology, among other things. Then, there is a lack of consensus and documentation among approach designers and this entire context is causing different situations:

- On the one hand, organizations do not know how they can take advantage of these approaches and how they can be helped in their particular context due to the diversity set of characteristics offered by these approaches and the global heterogeneity associated with specific aspects or ideas processed by each approach.
- On the other hand, under this situation it is very complicated for approach designers to identify the real organization's needs and demands in order to improve their approaches or design new ones.

However, within the context of the MDWE approach, WebRatio is an exception. This tool support provides a big community with a big variety of tutorials, webinars, user guides, support, forums and different types of tool certifications for users. Nowadays, there is no doubt that WebRatio is the leader tool in the market within the context of MDWE approaches, although neither this tool nor this community can be compared to other communities in the world related to Web development.

Opposed to the MDWE approach, there are existing and very extended Web development frameworks in the world like Ruby on Rails [30], Django [31], Grails [32] or Codeigniter [33], among others. All of them involve big communities of developers that provide lots of documentation, tutorials, user guides, forums and support, for instance. Moreover, these frameworks share many features and components that let developers compare them.

4.8.1 Guideline

These limitations and problems of description regarding the MDWE approach not only entail understanding these issues, but also unifying criteria and defining common strategies in a shared quality model [29,34,35]. Besides, this common model could help approach designers when improving or designing new approaches in the future. Besides, a common model can enable developers to compare all these MDWE approaches.

4.9 Licensing [E]

Today, two main business models to exploit these approaches in industry have been found on the MDWE approach.

The first business model consists in implementing a specific tool support for the approach from free source environments. This specific tool can be offered to organizations either by means of license fees or freely. As regards license fees, there are different types of charges for each tool depending on the case of the organization. According to existing license fees on the MDWE approach, we have classified costs in "High" (more than 5.000,00$ by activated seat), "Medium" (between 5.000,00$ and 1.000,00$ by activated seat) and "Low" (less than 1.000,00$ by activated seat) costs. For instance, WebRatio is developed under a free source environment like eclipse, but with extensions that transform the eclipse environment in a practical and valuable product like WebRatio, which is a powerful tool to support IFML visual modeling standard. In this case, WebRatio offers an enterprise edition license for which organizations must pay a fee for each activated seat. This charge can be classified as "High" cost.

The second business model consists in implementing the approach under the environment of a powerful but payment CASE tool support. Then, the use of the approach is free, but organizations must pay for its license. For example, the NDT-Suite is a supporting tool that is developed under the Enterprise Architect (EA) [36] environment. This CASE tool allows organizations to have and work with all elements of the NDT approach and, under the environment of EA enables organizations to work with concepts of the approach and lots of other visual modeling diagrams and characteristics that it additionally offers to organizations. One activated seat of EA license can be classified as "Low" cost. Other example of this business model is MagicUWE, which is a tool that has been developed for the computer-aided design of Web applications using the UML-based Web Engineering (UML) approach. MagicUWE has been built as a plugin of MagicDraw [37], which is a tool support that can be classified as "Medium" cost.

We must consider that organizations pay a fee for these licenses, only if they are guaranteed to receive the value they need with minimal costs, risks and incertitude. As regards tool support value, it is not possible to know what the most valuable approach is because it depends on the context. This way, each tool support has its strength and weakness points. It is the context that lets us decide which approach is the most suitable one. These tools can be incorporated in industry by maximizing their competitiveness: $Competitiveness = Value\ /\ (Cost + Risk + Incertitude)$

In fact, there exist other recognized and used frameworks in the market for the development of Web applications that they are not so abstract approaches, but effective solutions for developers. Frameworks like Ruby on Rails or Django, which encourage rapid development and clean pragmatic designs for developers, are completely free of costs. Finally, one of the most important points to highlight is that they are currently very extended solutions for developers. This way, this enhances companies' confidence to consider their use.

4.9.1 Guideline

Key questions are not only costs of a license, but also value (although it depends on the context), risks and incertitude that organizations assume with the implementation of these approaches and tools. Hence, it is important to offer a high-value solution, with no cost and minimal risk and incertitude for developers.

4.10 Summary

Finally, it should be noticed that several key points of the MDWE approach can be analyzed with the aim of improving the presented paradigm and allowing it to be applied in the current industry. In addition, it can show the capacity of evolution that the MDWE approach has as well as its potential development, if changes are applied for an improvement in Web development at present.

Essential aspects, such as: the control during the development and deployment of the application, traceability and errors debugging or, the rigidity of the architecture and technical aspects, may affect the development of our project. Considering this aspects, this paper evaluates the aforementioned points and check their level of acceptance.

In contrast, there are other aspects that are not focused on the development or deployment of web application, such as licenses, support community, navigation or supported metamodel, that must also be evaluated with the aim of improving other phases of the lifecycle.

5 Analysis of survey data

After establishing a series of hypotheses to the problems set out, it is necessary to carry out a study to gather information about the subject matter of experts in the field in order to be able to compare their knowledge and evaluate the results of their opinions. For this purpose, a survey has been carried out among a number of IT professionals from companies such as: Ayesa, Endesa, Everis, INPRO, Fujitsu, ATOS or Airbus D & S, among others. In particular, 50 users from the companies mentioned above have participated in the project. The objective of this survey is:

- The first part of the survey is intended to obtain information about the participants as well as the company for which they are working. This makes us differentiate among the different members surveyed.
- The second part of the survey tries to analyze the processes or procedures as well as the tools they use in their companies as well as their opinions.

5.1 Sample analysis

Firstly, an analysis of the participants of the survey is made to know data about the company they work in. The first thing consulted is the experience of the participants, an essential and relevant data for the final results of the survey. On the one hand, we can confirm that a large number of participants had many years of expertise in the sector. This allows us to obtain results endorsed by long-distance

professionals who still hold positions very close to the questions asked in this survey, such as Programmer Analyst, Project Managers or Senior Tester. On the other hand, this experience also allows us to extract more knowledge of the company in which they are working, since they have enough expertise to know how the company runs.

In contrast, the other participants can also provide the approaches of the staff that sum up less time in the labor market or in the company. Thus, we can check the different approaches of the selected sample.

Another question posed has to do with their academic positions. In this case, there are more graduate people among the most experienced selection than in the less experience group. Therefore, we can emphasize that there is a high-level knowledge among people selected for the survey. In addition, most of the participants do not have any certification oriented to the development of Web applications.

Secondly, we analyze the different companies from which the participants come. Approximately half of the organizations evaluated are companies that sell products based on Software, which allows us to obtain data from a sample with knowledge alienated with the issue of the problem that concerns us. Additionally, the remaining categorized subgroups have a number of participants needed to obtain information from other points of view that will further enrich the final data.

In order to better understand the sample to be analyzed, we have assessed the dimension of the evaluated companies.

Most of these organizations have a very large number of staff, for this reason we can consider that the results we get from the survey come from leading companies in the Software sector.

Finally, we also study the tools and technologies used by these organizations, which will serve to link these companies to the hypotheses presented here. On the one hand, participants were asked about the availability of a Web application development methodology or framework, to which most of the users answer that they do not have any standards for application development. On the other hand, the methodologies of SCRUM and CMMI are also very much extended in organizations.

As far as development languages are concerned, it is worth highlighting that the majority of companies use Java language, although it is far from .NET. Furthermore, when they are asked about the use of a framework for automating the development of web applications, only half of them use Spring, corresponding to Java language, as a framework of development.

In summary, we have a sample with several subgroups that are well differentiated and specialized in the subject to be treated. We also find participants from companies with a volume large enough to support the results in their dimensions. These companies show two clearly differentiated aspects regarding the use of frameworks for software development, so that they clearly run differentiated in terms of development.

5.2 Analysis of results

To begin the survey to obtain information about the topic addressed in this article, a series of questions have been raised related to the hypotheses set out above. Then the results obtained in the surveys will be presented and a comparison with the hypotheses will be carried out.

First, a question arises about the architecture of the applications in development to know its importance in the projects.

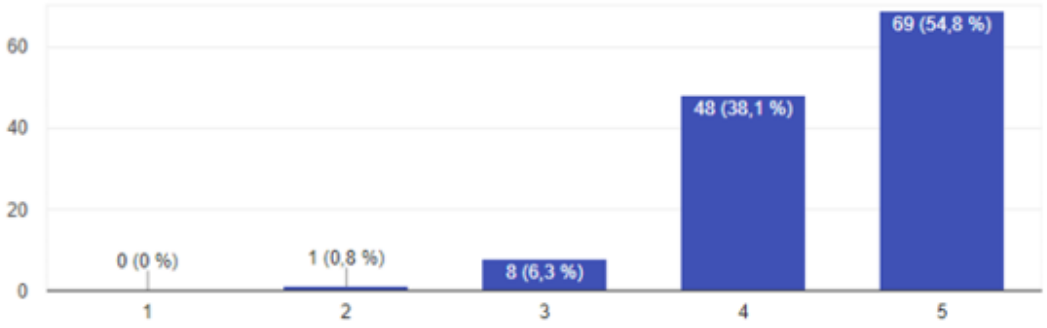

Figure 2: How important is for you to understand the architecture of the application you are developing?

As Figure 2 shows, most users consider that understanding the architecture of the application that is been developed is extremely important, specifically 69 of the participating users (54.8%) has marked this response. In general, 99.2% think that understanding the architecture of the application they are developing is important, what shows a consensus on the majority of the sample surveyed as well as in the opinion of most of the companies that are evaluated from the participants.

The next question asked to participants is to organize a series of activities according to the effort they entail in the development of their projects. The indicators range from activities that require greater effort, given value 1, to activities in which the effort is smaller, given value 6.

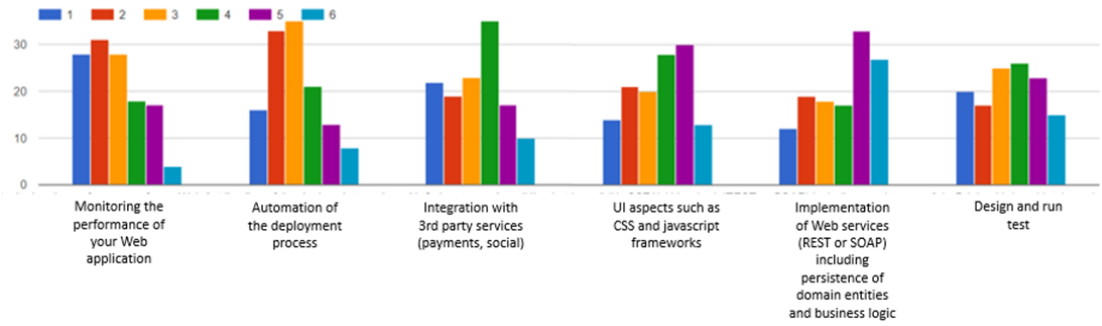

Figure 3: Please, rank the following activities according to the effort made in developing your projects.

First, we have analyzed the effort involved in designing the navigation of a Web application. Figure 3 shows that the results obtained are not totally helpful since the opinions of the users are quite different in this regard. The greater percentage is obtained in the middle zone of the chart, that is to say, an indicator of effort between 3 and 5.

Second, the next action to evaluate is to monitor the recognition of the application. As in the previous chart, quite high results are obtained in the beginning of the chart, although more differentiated. In this case, indicators 1, 2 and 3 shows that greater percentage of effort is obtained.

Third, another activity to be measured is the automation of the development process. In this case, the result shows similarities between indicators 2 and 3. It can also be observed that in Figure 3 other indicators are quite similar. Moreover, the chart related to the activity of integration of Web services is made by three parties.

In this case, the most outstanding indicator is the number 4, which represents a medium effort for most of the respondents. The following chart represents the development of aspects related to the user interface. It displays that the results with the highest percentage are those referring to indicators 4 and 5. Subsequently, the closest results are those corresponding to indicators 2 and 3.

To end up, the last chart refers to the implementation of Web services (REST or SOAP) including the persistence of entity model and business logic. Again, the higher results are those corresponding to indicators 5 and 6 that cover most of the total. Once analyzed the results referring to the effort involved in the development activities of the projects, we present the results obtained regarding the time available to implement and put into production a requirement, when a change has been requested during development.

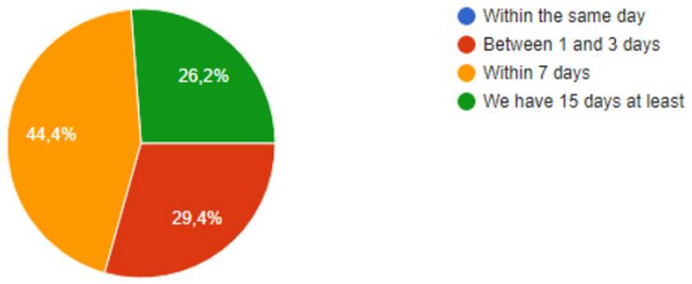

Figure 4: When a new feature or change request comes from the customer, how fast do you need to implement and deploy it to a production environment?

As Figure 4 lets us know, most of the users consider that the time available to implement and put into production a requirement when a change is requested during development is about 7 working days, as 44.4% of the participants think.

Below are the results regarding cases where there are some incidences in production. For this purpose, we will evaluate the importance of having traceability of causality of the incidence.

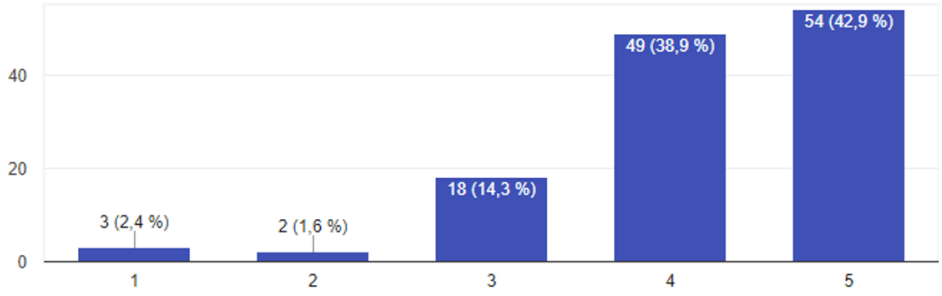

Figure 5: If you deal with production problem, how important is for you to trace back the problem to the development environment?

The results obtained in Figure 5 show that the majority of users consider that the fact of having traceability of the issues that could have caused an incidence is extremely important, being 42.9% the number of responses out of the total. This percentage, together with 38.9% of the very important responses, comprise 81.8% of the total responses, what remarks the relevance of this fact when dealing with incidents.

The next question posed to the participants is to order a series of elements according to the importance that these assume in the development and maintenance of their projects. The indicators range from the most important elements, given value 1, to elements that have a minor importance, given value 5.

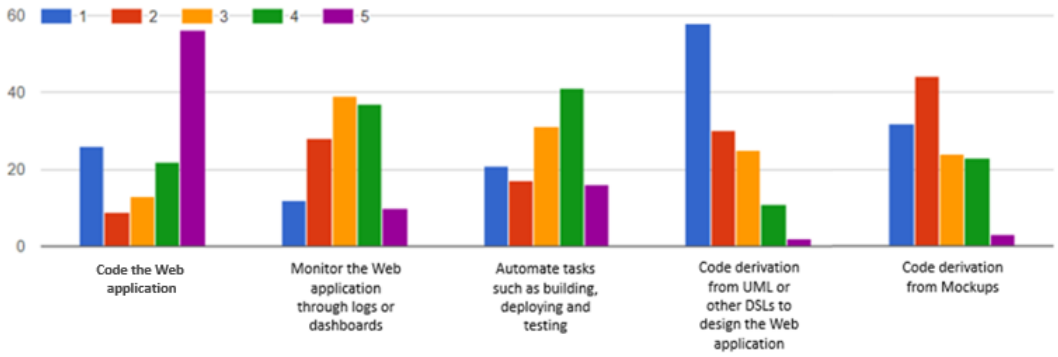

Figure 6: Rank the following items based on their importance for the development and maintenance of your Web applications

First, the importance of the code of Web application has been analyzed. Figure 6 indicates that the importance of the code of Web application is fundamental in a Web application.

Second, we present the results obtained in the query about monitoring Web application using logs or dashboards. In this chart, we can observe that the core values cover most of the users' responses, we can then define that their importance is medium.

Third, we show the results obtained in the automation of tasks such as construction, deployment and testing. Regarding this subject, the participants consider that these elements are important, but not the most important ones, since the chart concentrates most of the answers in the middle area of the chart.

Fourth, we present the generation of code from UML diagrams or other models used to design the application. Figure 6 represents that the importance for the users about the code generation is not their main priorities.

To conclude with the question about the ordering of a series of elements according to their importance in the development and maintenance of projects, we present the results obtained for the generation of code from mockups or prototypes of screen. All indicators except for 5 show similar results, out of which indicator 3 stands out.

Another question that asked in the surveys is the importance of knowing and controlling the architecture of a Web application, whose results are shown in Figure 7 below:

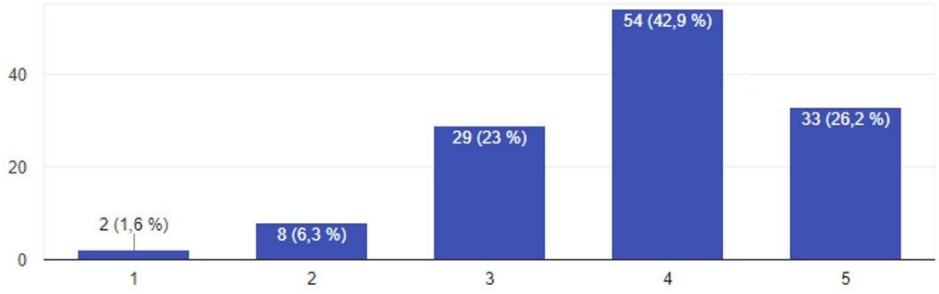

Figure 7: How important is for you to define the architecture of your Web application?

As we can observe in Figure 7, the set comprised in 92.1% of the sample considers that it is important to know and control in detail the architecture of Web application, highlighting it as the most chosen and relevant option.

The next question to the participants is to order a series of phases and activities according to the effort they need to be addressed. The indicators range from activities or phases that require greater effort, given value 1, to activities or phases in which the effort is smaller given value 6.

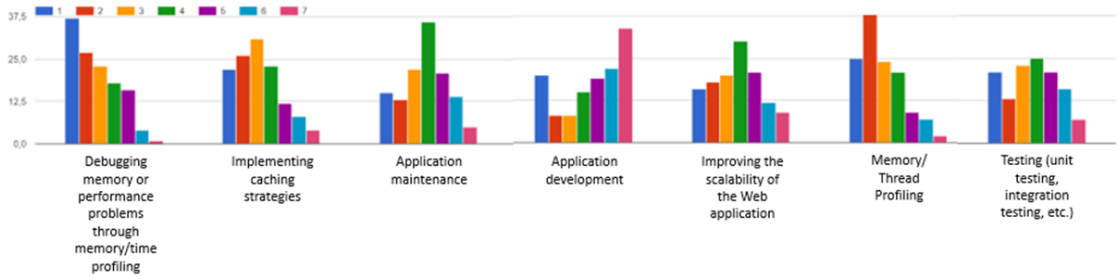

Figure 8: Please, rank the following aspects based on how much effort do you spend on each development iteration

First, we have analyzed the effort involved in debugging memory or performance problems. In the results of Figure 8 we can observe that we are facing an activity that needs a great effort of participants to be addressed, since the highest percentage of results is found in the first indicators.

Second, another of the activities that is evaluated is the implementation of caching strategies. The vast majority of the results are concentrated in the lowest indicators, which point out that for users, this task is not too expensive.

Third, and keeping on analyzing the results obtained, we present the effort that maintaining the application supposes to participants. As can be seen in Figure 8, the results are concentrated in the intermediate indicators, where indicator 4 predominates indicating that the effort of this task is not extremely expensive.

Fourth, it is going to show the effort that costs the development of the application. The results of this chart are equitable, highlighting indicator 5 as the highest value, followed by indicator 1, as the second most selected value.

Fifth, another important aspect to observe is the improvement of scalability of the application. The results are clearly located in the middle of the chart, what is a symptom that for participants it is a task that involves medium-high effort.

Following the presentation of the results obtained in the surveys, we describe the effort that the participants estimate of the profiling task or analysis of the application performance. In Figure 8, the results are concentrated in the initial zone where indicator number 2 stands out.

Finally, we show the results obtained for one of the key phases in software development, testing. This chart presents equitable values where it is not possible to clarify a response among all the indicators obtained.

After analyzing the effort of the development phases in the companies, it will be verified the importance that the participants give to the existence of communities and tutorials about tools and frameworks that are usually used in software development.

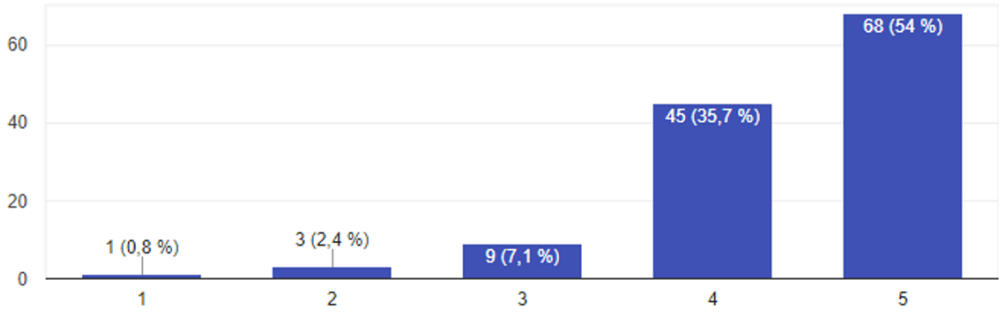

Figure 9: How important is the community and tutorials around the tools and frameworks you use for development?

Figure 9 represents that the values are concentrated in the highest options with 89.7% of the options selected in the values "Very Important" and "Extremely Important".

To finish with the presentation of the data of the surveys, there is a possibility that concerns whether the organization would be willing to pay for a license of a framework or tool that adds some value to the development.

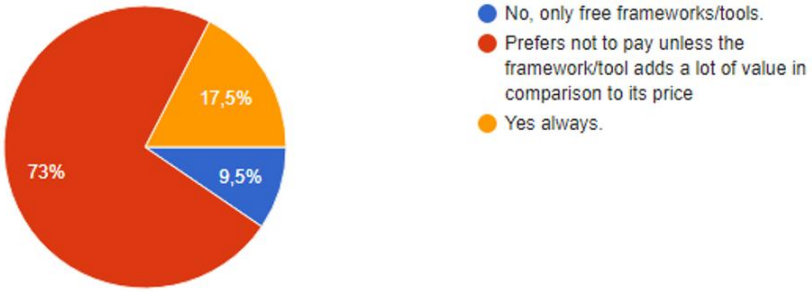

Figure 10: Is your organization/customer willing to pay a license to use a framework or tool that provides some value in development?

It is clearly observed that the values displayed in Figure 10 indicate that all companies prevent from investing too much in tools, especially in software, since they fall into disuse too early. For this reason, 73% of the participants condition the purchase of such license to the value that contributes the equally as well as its profitability.

6. Validation of results

Once the results of the surveys have been analyzed and presented, we will compare the information obtained with the hypotheses presented in section 3, Challenges.

6.1 Model extensibility through hooks

To begin, we will compare the results obtained from the survey with the hypothesis of using design patterns by means of the template method, as well as convert the code into an open source. For this purpose, we will look specifically at the charts of Automation of the development process where it is confirmed that the effort made in this task is relatively significant. It will also take into account the results obtained in the charts of code generation from other elements such as mockups, where it is observed the result of the survey giving this a considerably importance.

6.2 Open source

As for open source, it is important to highlight the chart Communities and tutorials on tools and frameworks in development, where 80% of the results state they are "very important". To conclude this hypothesis, it should be added that organizations prefer not to pay for a license of a tool unless the value it offers profitable outcomes, as indicated by 73% of the results of the last chart.

6.3 Need to include navigation

Continuing with the validation of the hypothesis, we proceed to verify the need to include navigation in the Web lifecycle, as well as a tool that supports it.

In this case, it has not been possible to obtain relevant data indicating the need to include this aspect in the lifecycle.

6.4 Time of the demands of the client

The next hypothesis that is going to be checked refers to the time of the demands of the client and how they can influence tools such as the metamodels. This can be seen in the chart of Request for change of a requirement during development, obtaining the highest result (44.4%) in 7 business days as the maximum period to respond to a request.

Then, the inclusion of the error detection features in the MDWE approach is done using the following charts:

- Charts regarding Traceability of what could cause an incidence, where we see that the majority of participants (81.8%) consider it a "very important" aspect.
- Monitoring of Web application through logs or dashboards that is of average importance among participants.

6.5 Tool to support the complete lifecycle

Next, we will check the need to find a tool capable of being modified in order to support the complete lifecycle.

6.6 Adaptive architecture

Later, the need to have an adaptive architecture that allows the development team to abstract high-level concepts using graphs that contemplate the importance of understanding and controlling the architecture of an application will be corroborated. This architecture allows that the majority of the users consider the idea of understanding this concept an important aspect.

6.7 Technical aspects to be supported by MDWE approach

Subsequently, the technical aspects to be supported by MDWE approach are verified and for them a series of charts corresponding to the measurement of the effort of the technical activities is used, where it is emphasized that all the charts center their highest values in the middle zone of the same.

6.8 Need of communities and tutorials

One of the last validations will confirm that communities and tutorials really need tools and frameworks as indicated in the chart on this topic, where most respondents agree that it is a necessary and important aspect.

6.9 Licenses

Finally, the topic of validations is completed with the hypothesis on the subject of licenses and the value they provide. The last chart expresses truthfully that organizations prefer not to pay, unless the value offered by such tools is profitable enough, exactly 73% of participants chose this option.

Finally, it has been interesting to summarize all these aspects described before. In this sense, Table 2 presents a summary of this survey with the results of each of the proposals.

Challenges	**Results**
Model extensibility through hooks	The effort made in this task is relatively high and important. Code generation is highly relevant
Open source	Organizations prefer not to pay for a license of a tool
Need to include navigation	It has not been possible to obtain relevant data
Time of the demands of the client	Request for change of a requirement during development. 7 labor days as the maximum term to respond to that request. With regard to validation of the inclusion of the error detection, the most important aspects concern traceability and monitoring of the Web with logs
Tool to support the complete lifecycle	A tool capable of being modified in order to support the complete lifecycle
Adaptive architecture	The majority of users consider that it is very important understanding this concept
Technical aspects to be supported by MDWE approach	The highest values are intermediate-value effort
Need of communities and tutorials	Necessary and important
Licenses	Prefer not to pay for them

Table 2. Summary of Survey

6.10 Threats to validity

There are several threats to validity that were considered during the experiment design. This research presents a preliminary result and for space sake

Construct validity. The experiment was designed to test a set of hypothesis based on a well-defined survey. In order to reduce the experiment's complexity and bias introduction possibility, we defined the survey as the only variable. Questions were non-ambiguous and a classic 5-point scale answer with no free content has been specified to mitigate any misunderstanding.

Internal validity. To mitigate these kind of threats, a homogeneous set of professionals has been chosen and filtered in order to avoid any external factor that may influence the answers. We pre-checked that all participants have had several years of expertise in the sector and also ensured that they currently have valuable industrial positions. Also, several different companies have been chosen in order to have answer diversity coming from different workplaces that may have internal practices that may vary from standards.

External validity. MDWE methodologies have more than 15 years and, as Model-Driven in general, they have demonstrated that there exist cases in which models can increase the productivity significantly. However, MDWE methods haven't reached big audiences as others like Agile. While this may compromise generalization of the results, this paper intends to answer a bigger question that is general in the Computer Science field: how much and in which contexts abstraction help to increase productivity in the different phases of the development cycle? This paper wanted to answer this question, which is a general one, in the context of web engineering. To mitigate this kind of issues and ensure generalization of this survey, our questions were carefully elaborated to include basic and core aspects of the web development process like architecture, logging, maintenance, profiling that are extremely important in enterprise contexts.

Conclusion validity. Every hypothesis described in Section 3 was backed by concrete results of the survey, which questions have been carefully designed to prove them in a Goal-Question-Metric-like fashion. Statistical significance was not a problem in this case since in this work no statistical tests have been required.

7 Conclusion and Future Works

To conclude, it has been possible to successfully verify many of the proposals raised in section 2 thanks to the participants of the surveys that share the needs presented. Despite this, not all the proposals have had the expected acceptance, since the needs of the respondents have not really clarified if the proposed solution fits each of them or is the same for all. Anyway, after carrying out the surveys and the possibility of improving some of the phases of the MDWE approaches with the proposals presented in this article, it can be seen that the acceptance and margin for improvement of this paradigm can be quite broad.

As future work, after the results obtained from the hypotheses raised, a line can be defined in the future of the MDWE approach. In this sense, the idea would be either to implement such solutions so that they can be integrated into the MDWE methodology by means of some tool or to expand existing ones. Apart from this, it should be noticed that the solutions proposed have not match the results of the surveys, thus it would be useful to provide new solutions to overcome deficiencies detected or even to evaluate again if such deficiencies really exist.

As we have seen throughout the paper, there are many fields by which this approach can be improved and in this paper we have focused on a small portion of them. As possible future work it would be very interesting to cover other fields such as security, usability or support for testing among others that improve the benefits of this approach.

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