Technical Tool Surveys and Comparative Studies: A Systematical Approach

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Abstract

Comparative studies and surveys on different technologies are common practices in research environments, not only when planning a new research line, but also in enterprise environment, for example, when a new project is going to be developed and the suitable technology must be selected. In the research context, an ordinary and formal method frequently followed to analyse the situation is the Systematic Literature Review (SLR). However, SLR is not enough, if the study is oriented towards comparing technologies or tools solutions. This paper presents a mechanism to be applied systematically in surveys and comparative studies of tools and technological solutions. It is based on general concepts defined in SLR, but it extends them in order to cover other necessities. The paper illustrates how this mechanism is applied to a real project named THOT and it offers conclusions and learned lessons from the last trends.
Keywords: Surveys, Comparative Studies, Systematic Literature Reviews, Enterprise Content Management.

1. Introduction

A Systematic Literature Review (SLR) is mainly carried out in order to find and develop innovative ideas for further research. In [21] authors consider SLRs as a means of completing processes based on identifying, evaluating and interpreting all available documents focused on particular research questions or theses in a specific investigation area. However, this process is not only associated with scientific environments. In fact, it can be applied to any domain or environment (such as research, enterprise or engineering, among others) as it is not only related to research work. In addition, it is normally used as a method for carrying out comparative studies on software tools or technology proposals.

Therefore, SLR aims to provide an exhaustive summary of literature relevant to a research, technological or technical question.

The use of SLRs is relatively recent in the Software Engineering (SE) context, but it has gained significant importance in this area as a means to identify, evaluate and interpret all available data to answer research questions on a particular topic in SE. It has been growing in importance as a systematic and structured approach regarding literature reviews since 2004,

when Barbara Kitchenham [9] proposed special guidelines that were adapted to cope with specific problems in the SE area. These guidelines have been used and evaluated [3] [10] [11] [18] in many contexts. Later, in 2007, Kitchenham's guidelines were updated [10]. Last year, Kitchenham's proposal was updated again [13] in order to be implemented, taking into account recent results published by software engineering researchers concerning their experiences when performing SLRs, as well as their advices for improving the SLR process.

Moreover, there are other ideas or views to conduct systematic reviews. For instance, in [20] [21], authors introduce different perspectives of SLRs. They issue their proposal after systematically selecting and analytically studying a large number of papers (SLRs) in order to understand the state-of-the-practice of search strategies in evidence-based SE.

In consequence, these SLRs proposals are highly directed towards answering research questions on some scientific knowledge. Nevertheless, SLR is not enough for a study led to compare technologies or tools solutions.

We have reached this conclusion during the execution of the THOT project. Such project is born because document processes management is becoming essential and critical within Andalusian Public Administration, due to e-Government is performing a key role in setting strategic plans.

At present, the THOT project is being executed by the University of Seville in liaison with the AOPJA (Agencia de Obras Públicas de la Junta de Andalucía). This is an innovative project on document management applied to service agreement records and transport infrastructure projects. It aims to analyze in detail strategies and document management systems (also known as ECM[1] or Enterprise Content Management), in order to investigate and define an innovative solution to improve records management.

There are many reasons for undertaking a SLR dealing with ECM solutions and its application to the THOT project. The most common ones are: (*i*) to identify what ECM systems currently exist in the market and what they offer for records management and documental processes; (*ii*) to identify how ECM systems can be adapted to the general guidelines of the Andalusian Public Administration in order to improve the records management; and (*iii*) to provide a framework to appropriately and objectively compare and facilitate decision-making regarding the most suitable ECM solution for the THOT project.

We have adapted the method proposed by Kitchenham to carry out the comparative study among ECM solutions. However, we have faced some trouble to successfully apply SLR due to our study's characteristics. We have also taken into account other authors such as Zhang [20] [21], Da Silva *et al.* [4] and Wohlin and Prikladnicki [19]. These works are summarized in Section 2.

In this paper we suggest a mechanism that can be used systematically in surveys and comparative studies of tools and technological solutions. It is based on general concepts defined in SLR, but it is extended to cover other necessities.

The paper is structured as follows: Section 2 shows the background of our proposal, which is described in Section 3. Finally, Section 4 and Section 5 present a successful case in which we have applied our proposal and some conclusions as well as future work, respectively.

2. Background

We have studied the most recent works on SLR guidelines to lay the foundations of our proposal, before describing the mechanism we recommend to be applied systematically in surveys and comparative studies of tools and technological solutions.

Zhang and Babar consider that SLRs are normally carried out in order to find out and develop innovative ideas for further research. A SLR is a means of completing processes based on identifying, evaluating and interpreting all available documents related to a particular thesis

[1] According to AIIM, Association for Information and Image Management, [1] ECM consists of strategies, methods and systems used to capture, manage, store, preserve and deliver content, and documents related to organizational processes. ECM systems and strategies facilitate the management of an organization's unstructured information, wherever that information exists.

in a specific investigation area. This process has its own terminology and is applied in different ways. In this line, Zhang and Babar introduce new vocabulary concepts and different perspectives on SLRs [21].

As the SLR process concerns, Zhang *et al* assume that designing and executing an appropriate and effective search strategy is a key step. [20]. Authors argue that these are time-consuming and error-prone activities and consequently, they need to be planned and implemented carefully. Authors also explain that there is an apparent need for a systematic approach to designing, executing, and evaluating a suitable search strategy for optimally retrieving the target literature. In light of this, they suggest an approach, which consists of a collection of known studies, and corresponding 'quasi-sensitivity' into the search process for evaluating search performance.. This idea was proposed as a result of selecting and studying a wide range of SLRs in order to understand the state-of-the-practice of search strategies in evidence-based software engineering.

Moreover, some authors put forward that the software engineering research community is starting to adopt SLRs consistently as a research method [4]. However, the majority of SLRs do not evaluate primary studies quality and fail to provide guidelines for practitioners, thus decreasing their potential impact on software engineering practice.

In [19], authors confirm that the search strategy is key to ensure a good starting point for the identification of studies and ultimately for the actual outcome of a particular study.

Finally, we have also considered the guidelines for the systematic review proposed in this paper according to the protocol defined by Kitchenmham *et al.* [13]. These authors establish that a SLR essentially involves three phases: (*i*) **planning the review**, which aims to decide which method will be used to carry out the review as well as identify and formulate the thesis that the systematic review must validate; (*ii*) **conducting the review**, which consists in finding and evaluating whether many primary studies associated with the research questions are adequate and relevant enough to be possible sources for further analysis; and (*iii*) **reporting the review**, which deals with writing up the results of the review and reporting them to potentially interested parties.

Figure 1 shows this process through a timeline that indicates when each SLR phase was applied within the THOT project.

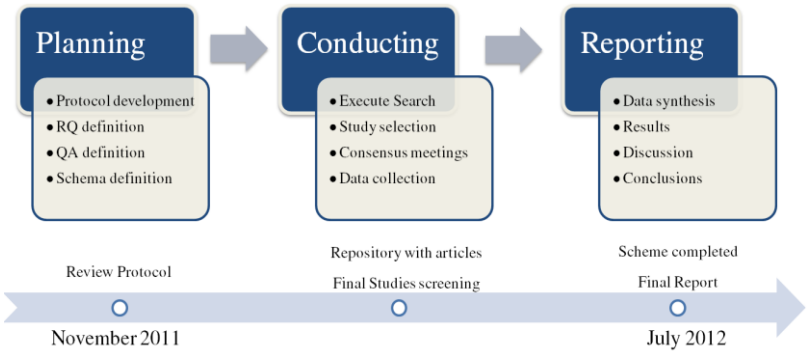

Fig. 1. SLR phases

SLR is seen as a valid formal method to carry out comparative studies and surveys of different tools or technological solutions, despite all these formal proposals. However, it is not enough since other necessities must also be considered. All these reasons make us recommend a mechanism (which is based on the well-known proposals concerning SLR) to be applied systematically in surveys and comparative studies of tools and technological solutions. Section 3 will further describe our proposal.

3. Our Approach

As it was previously mentioned, carrying out a comparative study of technical solutions can be very similar to conducting a SLR. However, the characteristics of technical comparative studies require special attention to some aspects.

This section describes the set of phases focused on the SLR approach presented in Figure 1. Then, we propose a characterization scheme to evaluate different alternatives of ECM systems, with the aim of selecting the most suitable one for the scope and context of this paper. This guarantees quality in the quality continual improvement process of these systems.

PHASE I. Defining the review protocol

In this first phase, the team has to plan the Review protocol of the study in order to delimit the specific context of the work. For this aim, we propose the use of classical elicitation techniques such as interviews, context analysis or checklists.

Three important elements have to be inferred from this phase:

1. Technical and Research Questions (TRQ). They represent which specific questions should the study answer.
2. Quality Assessment (QA). It defines each characteristic that has to be valued for each technical solution. They have to be traced with TRQ in order to answer them.
3. Characterization schema. It is the global result of this first phase. We propose to define a schema where each QA is represented. This schema has to be instanced and completed for each technical solution under study.

At the end of this phase, the team has to get a characterization schema similar to a check list**,** where each QA is represented in order to answer each TRQ.

PHASE II. Conducting the review

In this phase three different activities must be executed:

Activity 1. Preparing the search. At this point, the team has to define two different tasks:

1. To establish which search criteria will be used.
2. To establish which search sources will be applied.

According to the search criteria definition, we propose to follow the instructions referred in [17]. Search criteria have to be oriented to answer TRQ defined in Phase I.

With regard to search sources, it must be stated that the research search engines used in a SLR, such as ACM Digital Library, IEEE Xplore, ISI Web of Knowledge and so on, are obviously valid in a technical context. However, if we analyze the current situation of technical solutions, we assume that the use of other sources, such as Google or community blogs, among others, is completely necessary.

Activity 2. Executing the search. The search will take place, once the most suitable criteria and sources are defined.

Including other search sources, like Google or blogs, can increase the number of results to a greater extend than only focusing on research search engines. In any case, this activity has to be executed so many times as required in order to delimit which technical solution has to be considered.

Sometimes, it can be very useful to re-analyze the QA defined in Phase I, because they are too ambiguous or concrete, which is likely to provoke two dissimilar consequences; that a large number of technical solutions or none of them can be found.

Another technique that can be useful to delimit the set of technical solutions under study is the analysis of the functional context. We have to keep in mind that our approach is oriented towards comparing technical solutions for a specific problem. Thus, the team could discuss with functional users the set of QA and technical solutions found in order to analyse their suitability for the concrete functional context.

Activity 3. Comparative evaluation of ECM systems. The characterization scheme obtained from Phase I has to be instanced in each approach, after the technical solutions under study (TUS) have been defined.

However, we propose that the team execute another activity before instantiating the schema in order to evaluate the technical solutions.

It is usual to find characteristics that depend on the person who carries it out in the technical evaluation. For instance, usability depends on final users expertise. For this reason, this activity should be divided into three tasks:

1. To define evaluation teams. Studying the set of characteristics, we propose to define the group of people who has to assess each of them. Thus, evaluation subset can be defined in order to obtain different point of views. As it is presented in our example, for instance, we have three different evaluation groups, depending on their expertise on ECM solutions.
2. To instance the schema for each approach in every evaluation group. They, independently, have to value each characteristic in the schema for each TUS.
3. To consolidate the results. After the independent valuation, evaluation teams must arrange a meeting to analyze the individual results and agree a common and unique consolidated result for all evaluation groups.

PHASE III. Reporting

The last phase requires the active participation of the functional team. In this phase, the results obtained from phase II are compared and studied, and each TUS is analyzed in detail in comparison with the rest of TUS.

Using a characterization schema is essential for this phase because it offers a concrete and similar assessment for each approach. The evaluation team can compare every TUS using the same criteria and vocabulary for each of them, which helps setting the final conclusions.

Final reports of the comparative study must be issued at this phase.

4. An Example

The review has been conducted for an effective characterization of ECM systems. We have multiple criteria to calculate the preferences the characterization scheme elements demand. Thus, it is a multi-objective optimization problem, for it is not only important to implement the most valuable ECM system, but also to reduce cost, risk and incertitude.

We will explain how the ECM systems have been analyzed and evaluated and how the comparative evaluation has been carried out.

The guidelines for the systematic review have been explained in previous section. Nevertheless, this proposal initially centers on the systematic review of research studies. For this aim, we have adapted this proposal to focus on studies of ECM systems and all those related fields. A SLR essentially involves three phases: (i) planning the review, (ii) conducting the review and (iii) reporting the review.

- The stages associated with planning the review are: identification of the reviewer's needs, specification of the research question(s), development and evaluation of a review protocol.
- The stages related to conducting the review are: identification of the research, selection of primary studies, study of quality assessment, data extraction and monitoring, and data synthesis.
- The stages concerning reporting the review are: specification of dissemination mechanisms, formatting the main report and evaluation of that report.

The planning phase has two main goals; on the one hand, deciding on which method will be used to conduct the review and on the other hand, identifying and formulating the thesis that the systematic review will prove. Regarding the first goal, as stated above, the method proposed by Kitchenham et al. [13] will be followed, but taking in consideration other authors like Zhang et al. [20] [21], Da Silva et al. [4] and Wohlin and Prikladnicki [19]. Nevertheless, with this systematic literature review, this work aims to answer the next questions in relation to the second goal.

- *Question 1*.- What ECM systems currently exist in the market and what do they offer?
- *Question 2*.- How ECM systems can be adapted to the general guidelines of the Andalusian Public Administration?

- *Question 3.*- What is the most appropriate ECM system the Andalusian Public Administration, and more specifically, the Contracting Services for Transport and Infrastructure Constructions must use?
- *Question 4.* - What areas of improvement are needed for the selected ECM system?

A large number of identified search keywords picked up from these questions have been used in the review process. Some of them are: "Solutions for Managing Enterprise Contents", "ECM in Real Environment", "Software for Managing Document Processes". In addition, the following databases have been considered in the systematic literature review: ACM Digital Library, Ei Compendex, IEEE Xplore, ISI Web of Knowledge, Science Direct, SCOPUS, Springer Link and Wiley InterScience Journal Finder.

Once all planning phase goals have been achieved, the revision process enters in the review phase, which consists in finding and evaluating the adequacy and relevance of many primary studies associated with the research questions as possible sources for further analysis. The primary studies will be searched through the aforementioned databases by means of our keywords. Then, a strategic plan for evaluating the adequacy and relevance of the studies is needed after the search is executed.

Firstly, keywords are looked for each logical criterion in the search field included within the aforementioned databases. Secondly, the set with the previous primary studies is reduced according to the following inclusion criteria:

(a) The primary study must have been published in the last four years, that is, from 2010 to 2013 (both included). This exclusion criterion is considered realistic and acceptable in the context of this work, because the number of ECM systems and versions has increased in the last years. Therefore, the selected primary study must be recent in order to infer useful conclusions.
(b) The paper must focus on Computing Science.
(c) The paper must have been published in any influential magazine (for instance, JCR or Journal Citation Reports).

Thirdly, a new discrimination has been conducted by means of a fast reading of each primary study. That means, the title theme of the primary study must be linked to the topic of this work. For example: «ECM», «Enterprise Contents Management» or «Document Process». Once this condition was satisfied and this primary study cataloged as promising, the introduction and abstract must mention the goals of the research questions posed in this section.

Finally, after carrying out this review, we have neither found concrete solutions for ECM systems nor studies on them. In contrast, we have discovered some work associated with theoretical proposals in the context of ECM systems. Therefore, classic search engines and the Internet have been selected in order to carry out a specific survey of this type of systems. In addition, we have also considered the last Gartner's analysis concerning Enterprise Content Management. Gartner [7] is an international research and consulting company dealing with Information Technology. This study is popularly known as Magic Quadrant and was presented in October 2012. It consists in evaluating 15 weighted criteria that are based on their relative strengths in the market. They depict markets by using a two-dimensional matrix that evaluates vendors according to their completeness of vision and ability to execute. Moreover, in this second search, we have considered several pre-selection criteria.

After this second search and in accordance with Gartner's Magic Quadrant for ECM, we will evaluate the following systems (in alphabetical order): Alfresco [2], Documentum [5], Nuexo/Athento [14], IBM FileNet [8] and OpenText [15].

According to all these analyzed systems and the strategy that we will follow, we propose a set of preferences for each element of the characterization scheme that has been defined (we will cope with this definition in the next section). For instance, the weighting established by Gartner for basic functionalities listed above is: Document Management: 0.15, Document Imaging / Image-processing applications: 0.18, Workflow / BPM: 0.22, Records Management: 0.13, Web Content Management (WCM): 0.7, Social Content / Collaboration: 0.15 and Interoperability / extended components: 0.10.

Thus, following Gartner's criteria, this set of preferences will be defined to adapt the characterization scheme to our project scope. Taking into consideration that we are looking for

the most complete system, the rest of preferences will be thought as important as each set of elements.

The characterization scheme is understood to encompass all the relevant characteristics to analyze ECM systems. We have defined basic characteristics following the recommendations of SEG research group defined in [17] to establish an objective comparative framework. The goal of this paper is to introduce the methodology for performing rigorous reviews of existing empirical evidences into the software engineering community. The advantages of defining these characteristics are to present and evaluate schematically and homogeneously each of the solutions under study. Moreover, this characterization scheme allows setting each evaluation criteria in a clear, concise and unified way.

Our characterization scheme is composed of ten prioritized features, which answer the questions defined in the previous section. This priority is contextualized within the needs of our project: to define an innovative solution for document management applied to procurement of services and transport infrastructure projects within the Regional Government of Andalusia (Spain). Below, we illustrate this characterization scheme: Features (FT) and their Sub-Features (SF).

FT01: Functional **modules**. The results obtained in the characterization schema Strategy phase point out that a valid ECM system must include natively and minimally the following functionalities. Next, we describe the Sub-Features of this Feature: *SF01*: Document Management, *SF02*: Records Management, *SF03*: BPM (Workflow/ Business Process Management), *SF04*: Document Imaging/ Image-processing applications, *SF05*: Interoperability functions/ extended components, *SF06*: WCM (Web Content Management) and *SF07*: Social content/ collaboration.

FT02: User Orientation. Although ECM systems offer standard solutions on its orientation towards the end user, many companies need using easy and versatile systems because not all their employees have the same user profile to handle computer tools. Next, the Sub-Features of this Feature are described below: *SF01*: Usability compliance, *SF02*: Accessibility, *SF03*: Document preview, *SF04*: Drag & Drop, *SF05*: Bulk uploads, *SF06*: Undo, *SF07*: WYSIWYG Editor (What You See Is What You Get), *SF08*: Customization, *SF09*: Groups and Social networks and *SF10*: Multilanguage.

FT03: Functionality to capture, access, retrieve and view documents. The ability to capture, access, retrieve and display, within the group, includes those features that let anyone customize the system according to the preferences of users or the organization being implemented. Next, we describe the Sub-Features of this Feature: *SF01*: Degree of Cataloguing, *SF02*: Agrupation, *SF03*: Thesaurus Support, *SF04*: Digitalization, *SF05*: Bulk Upload, *SF06*: Content Generation, *SF07*: Office Integration, *SF08*: Forms and Templates, *SF09*: Integration Forms Managers, *SF10*: Advanced Search Methods, *SF11*: Search Algorithms and *SF12*: Display Formats.

FT04: Documental Life Cycle. This Feature enables us to assess the level or degree of support the system offers to the document cycle. Next, we describe the Sub-Features of this Feature: *SF01*: Check-in Check-out, *SF02*: Life cycle, *SF03*: Versioning Support, *SF04*: Actions traceability, *SF05*: Inconsistencies management, *SF06*: Dissemination management, *SF07*: Conservation, *SF08*: Destruction and *SF09*: Physical actions.

FT05: Workflows. This Feature can assess whether the tool supports management with business processes. Next, we describe the Sub-Features of this Feature: *SF01*: Supported standards, *SF02*: Management support, *SF03*: Available options, *SF04*: Motorization, *SF05*: Simulation and modeling, *SF06*: Graphical utilities and *SF07*: Task management.

FT06: eGovernment. Measuring the support and features involving eGovernment is essential, given the context in which this project is developed. This group of features measures the degree of support offered in this context. Therefore, we can evaluate whether the system allows accessing and using valid electronic documents according to the Spanish National Interoperability Scheme guidelines. The Sub-Features of this Feature are described below: *SF01*: Electronic documents, *SF02*: Digital signature, *SF03*: Accreditation and representation, *SF04*: Indexes support, *SF05*: Unique identification, *SF06*: Minimum metadata, *SF07*: Classification plan support and *SF08*: Official time synchronization.

FT07: Interoperability Compliance. A specific section dealing with interoperability has been included: Integration with tools. This Sub-Feature evaluates whether the ECM system provides mechanisms (e.g. APIs) to integrate with third-party tools. Next, we describe the Sub-Features of this Feature: *SF01*: Connection, *SF02*: ERPs, *SF03*: Capture tools, *SF04*: Email, *SF05*: CMIS repository, *SF06*: Web services, *SF07*: Single window, *SF08*: Electronic record, *SF09*: Records manager, *SF10*: Electronic files, *SF11*: Digital signature, *SF12*: EAI and *SF13*: Streaming.

FT08: Security and Control. One of the major objectives of document management solutions is to ensure information security, by controlling access to the system from inside and outside the organization and manage the documents including such information either to archive or destruct them. Consequently, these solutions must provide services that ensure that the information stored is secure. It evaluates whether the system is functional enough to analyze data, or otherwise, whether the system allows using third-party tools. Next, we describe the Sub-Features of this Feature: *SF01*: Exportation, *SF02*: Data Analysis, *SF03*: Activity indicators, *SF04*: Granularity, *SF05*: LOPD, *SF06*: Logs. *SF07*: SSO and *SF08*: Notifications.

FT09: Architecture. Open architecture. It evaluates whether the system has an open architecture (i.e., the system allows adding, upgrading and changing its components) or a closed architecture (i.e., the software manufacturer chooses the components, and the end user does not intend to upgrade them). Next, we describe the Sub-Features of this Feature: *SF01*: Open architecture, *SF02*: Browsers, *SF03*: Mobility, *SF04*: Development kit, *SF05*: Cloud solution, *SF06*: Administrative capabilities, *SF07*: Programming language, *SF09*: Multiplatform, *SF10*: Extensibility, *SF11*: Volumes, *SF12*: High availability and *SF13*: Scalability.

FT10: Cost. Cost (both initial and long-term by maintenance) is one of the most important factors any organization must take into account when choosing an ECM solution. Next, we describe the Sub-Features of this Feature: *SF01* Licenses, *SF02* Infrastructure, *SF03* Open source, and *SF04* Maintenance and support.

FT11: Assistance and RM (Roadmap) Support. This last Feature listed in the latter group includes aspects for the evaluation of the Characteristics support, assistance and roadmap provided by the ECM solution. Next, we describe the Sub-Features of this Feature: *SF01* Certification program, *SF02* User Manuals, *SF03* Service support, *SF04* Formation service, *SF05* Roadmap and *SF06* Manufacturer online assistance.

Along this first iteration, lots of new trends were sensitive of being included in the characterization. In fact, we started the project just considering Alfresco [2], Documentum [5], IBM FileNet [8] and OpenText [15]. Then, in a second iteration we included Nuxeo/Athento [14] and KM [16]. Nevertheless, KM was discarded in the characterization phase because this system did not comply with our project scope purposes, thus Nuxeo/Athento was finally considered.

In the THOT project, we needed to decide what ECM system was the most suitable for our project scope (Andalusian Public Administration, in Spain). As a result, we defined our characterization scheme and each set of preferences for our characterization scheme elements. Therefore, we used a Quality Evaluation Framework (named QuEF) [6] for analyzing and evaluating ECM systems. Moreover, QuEF provides a flexible and efficient solution based on a Web environment, so that organizations can choose the most suitable ECM system for their purposes as well as enforce the quality continual improvement of these systems in the organization.

In the QuEF framework, we used this weighted characterization scheme as a quality model in order to analyze and evaluate the different systems. Thus, in this framework, the quality model was used to manage the comparative evaluation of ECM systems, which were analyzed by means of checklists. These checklists were artifacts generated automatically by the tool support of QuEF, which contained all Features and Sub-Features that we defined to analyze an entity. Consequently, we used all these checklists in order to know the current state of an ECM system and select the most suitable one.

5. Conclusions and Future Work

This paper presents the results of a research project that has been carried out in a real environment. The THOT project is an e-Government project that aims to implement an ECM system in the Andalusian Public Administration, in Spain.

This paper focuses on the first stage of the project and explains how the technological and functional status of ECM systems has been studied. Strategically, it is very important to evaluate all existing alternatives in the market in order to align the scope and purpose of the organization. Besides, a static evaluation is not enough because new improvements to existing systems are continuously appearing and it is necessary to be able to compare alternatives dynamically and objectively. In addition, we have to consider different preferences of the elements that contain an ECM system in terms of our specific context.

The THOT project challenges to innovate research. Although our research group (the Web Engineering and Testing Early, IWT2) has already worked and has mature experience in many aspects of the project, the integration of all the elements into a project of this size and the ability to validate research results and transfers arouse interest to the user and provide elements that will enhance the future work of this research group.

Finally, the project tends to solve the environmental problem by applying principles of e-Government in the public procurement activity, promoting the conversion from paper to electronic media in written communications between managers as well as an efficient and effective strategy with the consequent socioeconomic impact.

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