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A Set of Prescribed Activities for Enhancing Requirements Engineering in the Development of Usable E-Government Applications

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Abstract

Over the last years, e-Government applications have become indispensable in every country as they help stakeholders carry out tasks with the administration. However, and despite their growing usage, most of these applications are created through a developer-centered approach instead of a user-centered one, using traditional development processes that do not fit well with the diversity of stakeholders and existing legislation that involve e-Government applications today. Besides, usability is an important clue in the development of such solutions, so a user-centered approach, combined with a successful stakeholder and legislation analysis, should be considered overall. This paper is focused on addressing these concerns, and it provides a set of prescribed activities, tasks and products to be carried through a user-centered process in order to design usable web-based e-Government solutions. Specifically, our approach considers requirements engineering activities enhancing usability by analyzing the diversity and interests of the stakeholders involved, as well as the specific legislation as a source of organizational requirements. In addition, a validation is provided through a case study, showing the feasibility of the approach presented.

Keywords

E-Government, Stakeholder Analysis, Legislation Analysis, User-Centred Development Process, Requirements Engineering, Usability.

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1. Introduction

As time goes by, there is an unmistakable evolution in the way people interact with technology. One example of such interaction is related to the way citizens interact with their government, which led to the concept of e-Government [1], generally defined as the use of ICT (Information and Communications Technology) to transform the relationships between government and society through the efficient and effective usage of information and services.

According to that, citizens are one of the main beneficiaries of e-Government initiatives, so that developments should be principally focused on such group. However, the maturity level of e-Government implementations is unequal around the world. Actually, some existing implementations are mainly focused on transforming internal processes to achieve goals based only on functional quality attributes [2]. Therefore, there is a growing need to improve the mainstream and establish user-centered initiatives for e-Government, focusing on citizens with a special emphasis on their needs and the socio-economic aspects that determine their behavior and habits [3]. In this sense, it seems appropriate to research specific activities and techniques in the area of Human-Computer Interaction and Software Engineering for the development of e-Government applications improving usability as a key quality characteristic.

To take up this challenge, several aspects concerning stakeholder diversity [4], governmental legislation and user-centered activities and techniques should be addressed. Therefore, this paper analyzes the special characteristics of an e-Government environment where different stakeholders with conflicts of interests may exist [5]. Also, an e-Government application sometimes implies a heavily regulated development due to laws and legislations, where the use of traditional development process models may fail. To this respect, this paper proposes activities and techniques related to legislation analysis, thus producing specific organizational requirements through a user-centered approach.

The following research questions are stated, and they will be answered through the evidences reported along the paper:

- **RQ**_i: Are most of the existing software development models conceived from a technical perspective, lacking a prescription of specific activities to jointly address the identification and analysis of different stakeholders and the existing legislation as a source of requirements for the design of usable e-Government software applications?
- **RQ**_i: Is it possible to propose specific software development activities and techniques, and integrate them into a user-centered development model, with the aim of producing usable e-Government applications? Can it be done by considering usability issues, identifying and analyzing the stakeholders' main interests and conflicts, and including existing legislation as a source of requirements?

According to these, the main contributions of this paper can be summarized as follows:

- A detailed method to analyze and classify different stakeholders considering their interests and conflicts in a systematic way.

- The prescription of 6 development activities specifically focused on context and user analysis, as well as on requirements elicitation. Those can be integrated into the ISO 9241-210 [6], which lacks of specific tasks prescription, as the basis for the user-centered process model. For each defined activity, objectives and concrete implementation aspects are detailed, featuring a total of 14 specific tasks and sub-tasks. Also, for each task, input and output documents have been defined, contributing a total of 16 products. Proposed activities can be combined with others required by developers. In fact, there is no need to accomplish all the proposed activities, as this mostly depends on the project's characteristics.
- The prescription of 1 activity for product quality assurance, also integrated in the aforementioned user-centered model approach.

The proposed solution represents an alternative to facilitating the user-centered development of e-Government applications, providing software professionals with a systematized context-specific development framework. Additionally, the solution allows the participation of different stakeholders in the design of the e-Government solution, also considering the existing legislation as important development requirements. As far as usability is concerned, the proposal is intended to increase enduser satisfaction and ease of use. Also, the approach is aimed at improving productivity in application development, decreasing design errors by considering solutions that include all involved stakeholders and conform to current legislation. Finally, our approach is also intended to improve maintainability by reporting useful documentation through the developed products.

This paper is structured as follows. Section 2 reports on related work concerning the principal issues covered in this paper. Section 3 presents our approach, describing the stakeholder analysis method and the development activities, tasks and products in detail, providing an integration framework through the ISO 9241-210. Section 4 includes a validation of the approach through a case study, showing some of the output information generated. Finally, Section 5 presents conclusions and future work.

2. Related Work

In order to tackle the problem proposed and find out existing solutions, we carried out different bibliographical researches, including a Systematic Mapping Study [7] aimed at formally searching current literature to identify existing approaches. Once the results were analyzed, it was confirmed the absence of specific works that directly address the problem stated, as most of the related papers found just address the problem partially.

In general, the processing of usability, stakeholder and legislation requirements together is rarely systematized, and it greatly differs from one approach to another. Most of existing approaches consider stakeholders, legislation and usability as a source or non-functional requirements, and they are commonly catalogued and barely discerned for a proper and joint analysis [8-14]. In fact, the correct handling of non-functional requirements can be identified as one of the most important areas of research [8]. Sometimes, there is even a certain confusion and repetition among user and stakeholder requirements that leads to a quality defect [9]. Also, uncontrolled participation in requirements engineering leads to conflicts and representativeness problems [10], as well as to a misinterpretation of legal requirements if they are tackled by non-expert

[11] or improperly managed through the inexistence of a suitable engineering process. For the most part, first pre-design stages related to understand and specify context of use or user requirements are rarely in-depth considered in e-Government solutions [12]. Some approaches, such as [4], include a requirements engineering process to consider a large number of stakeholders, but considering only a specific geographic area, and overlooking usability concerns and specific legislation requirements as *a must* for requirements analysis. Other approaches, such as [13], define formalisms to incorporate usability requirements in the development process. However, this approach is mainly focused on the architectural design, lacking of a concrete requirements engineering process. Other approaches make use of models for representing legal requirements in a specific context [14]. However, while reporting important added value by enabling simulation, stakeholder and legislation requirements should be analyzed together, in order to identify conflicts of interests in a broader context, such as in e-Government applications.

All in all, we present in this section the principal related work found that we have split into three different sections according to the main topics addressed.

2.1. E-Government

Over the years, there has been an evolutionary vision of the e-Government concept in the literature. In general, it is considered as an ambiguous and ever-changing field [15]. This is because, somehow, the e-Government is a reflection of the strategies and the particular political context in which it is implemented [16], and it is generally defined in terms of the goal of its implementation, rather than in terms of the specific technologies used or the activities involved [17]. According to Relyea [18], the term e-Government was initially introduced in 1997 as Electronic Government or e-Gov. This way, the e-Government appears as a way to improve public access to governmental services; a necessary change in response to the many technological advances and its associated effects, and the huge number of governmental functions and services already existing [9]. In general, the e-Government is often used as a symbol or an ambiguous reference to the government's ICT applications, conceived to achieve greater efficiency and effectiveness in the processes being performed [18]. Means and Schneider [19] provided a more evolved definition of e-Government as the relationship between the government and their customers and suppliers using electronic technology, where customers and suppliers can be citizens, companies, other governmental parties, etc. This was actually an interesting evolution of the term where a business perspective was considered, also identifying citizens requiring governmental services, as well as other stakeholders such as governmental agencies. This led to one of the most accepted definition of e-Government as the utilization of Information Technology (IT), ICTs, and other telecommunication technologies to improve and/or enhance efficiency and effectiveness of service delivery in the public sector [20]. Depending on the stakeholders involved and their interaction, different e-Government delivery models were proposed: interactions between a citizen and their government (C2G), between government and governmental agencies (G2G), between government and citizens (G2C), between government and employees (G2E), and between government and businesses/commerce (G2B).

Optimization of governmental processes is one of the main objectives for the implementation of e-Government, as it is required to incorporate ICT tools in

governmental agencies for a successful implementation of specific functions. Also, it is necessary to optimize internal processes to support new technologies and services as well as the information offered [3, 21]. In this sense, Layne and Lee [22] developed a maturity models, called Four-Stage Model, to classify the evolution of e-Government applications through a technological and operational perspective. Similarly, The United Nations developed The Four Stages of Development of Online Services [2], a more evolved maturity model intended to measure the degree of development of e-Government applications in different countries. This model is commonly used as an indicator in global reports on e-Government, and it consists of a pyramidal model representing the evolution of e-Government services, primarily focusing on the perspective of the citizen. This way, the stages of the model are based on how citizens perceive online services through e-Government applications. In this model, emerging online services can be found at the bottom of the pyramid, which are the most common and easy to implement. By contrast, online services, which imply highly functional and fully connected e-Government applications, are on the top of the pyramid.

Different architectural approaches have been elaborated to establish the structure and goals of enterprise applications. To cite a few, Zachman Enterprise Architecture Framework [23] can be useful to organize the structure of an e-Government solution as a matrix representing the intersection of particular focuses and perspectives, where each perspective is related to roles such as the planner, the owner, the designer, the builder and the subcontractor. Zarchman Framework has been used to provide guidance for federal cross-agency architectures [24], separating viewpoints and views to create architectural models and building blocks [25]. Another application consists in identifying the different abstractions to describe the real work and therefore the different perspectives of the role that a stakeholder may take [26]. However, Zachman approach does not prescribe any concrete activity, as it can be conceived as an architectural framework. Another similar approach comprises the 4+1 view model [27], which allows to describe the architecture of a software system based on multiple views, thus identifying stakeholder interests with respect to the software architecture. The approach can be useful to classify stakeholders into different views – i.e., a logical view for end-users, a process view for system designers and integrators, a development view for developers and managers, and a physical view for system designers; in addition, selected use cases or scenarios can be used to depict the architecture for end-users and developers. However, this approach is useful to analyze stakeholder interests from the architectural point of view, missing other perspectives (i.e., usability and accessibility) that can be important in e-Government applications.

2.2. Stakeholders

The concept of stakeholder first appeared in the private business sector referring to persons who can affect or be affected by the actions of a business as a whole [28]. However, the stakeholder theory can be also applied to the public sector, especially in e-Government initiatives [29]. This is because the implementation of e-Government requires the participation of a wide range of stakeholders, some of them are indispensable for the development of integrated services, in contrast to previous approaches [30] where the implementation of information systems in the public administration was carried out in isolation [31].

Rowley [32] identified different stakeholders depending on the role they play for a

successful implementation of e-Government initiatives. The study was conducted considering experts in the field, obtaining a classification of the main benefits and/or interests that each stakeholder seeks. The existing diversity came to light – i.e., while citizens are primarily interested in features such as ease of use and transparency in e-Government applications, stakeholders in the private area, such as small, medium and large businesses, look to reduce their administrative burden, and increase productivity and profitability in their processes.

One of the main problems in implementing e-Government solutions is the inadequate consideration of the stakeholders impacting in the software development, an issue that usually occurs in requirements engineering [33]. In fact, one of the principal problems in implementing IT projects for the public administration is that efforts are mainly focused on technical aspects, ignoring organizational aspects [34]. These problems are caused by the incorrect identification and analysis of involved stakeholders [35], which is one of the critical factors in the successful implementation of e-Government initiatives [36], and the lack of this activity is one of the main causes of failure in developing e-Government projects [37]. Therefore, identify, characterize and analyze the different stakeholders' views and needs becomes a critical task in the development process [38]. Therefore, it is necessary to consider the views and needs of all stakeholders together, jointly identifying interests and conflicts what leads to implicitly improving the quality of the e-Government application to develop.

2.3. Development Processes

Another important issue to consider is the development process to design e-Government solutions. In this sense, different concerns should be considered due to the heavily regulated nature of the public administration [39]. As a matter of fact, the implementation of e-Government applications cannot be exclusively focused on the user's needs due to the differences in how they perceive the tasks to be performed during the interaction with the government, given the underlying laws and regulations. It is also necessary to consider the way users behave while performing a complex process, since according to the case study by Kotamraju and van der Geest [40], when a user faces a mandatory requirement, it is only perceived as an unimportant drawback, and s/he tries to find an alternative way to get around it. Generally, mandatory requirements and citizen processes are defined by laws and regulations [41], which are often unknown by the citizens, thus it is likely that the citizen's vision differs from what is defined by law.

One of the most important aspects in the selection of the development process is the existence of user analysis activities to contextually characterize tasks. Although this facility can be found in existing user-centered process, most well-known models inspired by User-Centered Design (UCD) are principally based on end-users, and they do not explicitly support stakeholders and regulations analysis. In addition, specific characteristics such as process-flow, refinement and feedback facilities should be considered, so iterative and/or incremental process are suitable rather than sequential ones, since the idea is to carry through an evolutionary user-centered development.

Several representative UCD-inspired process models were revised, such as the Usability Engineering [42], the Usability Engineering Life Cycle [43], the Scenario-Based Development [44] and the Usage-Centered Design [45]. However, after a broad analysis, it can be concluded that none of them is entirely appropriate for e-Government

development as they do not include specific activities for stakeholder analysis, nor do they explicitly consider legislation as a source of requirements.

Only the standard ISO 9241-210 [6], which replaces the previous ISO 13407, is suitable to be used as the basis for a user-centered e-Government development process, since it recognizes the importance of identifying stakeholders and their needs, and there is room for the analysis of existing legislation that can be included as organizational requirements. This standard addresses usability from different stakeholder perspectives - i.e., end-users, organization and technical people [46], identifying different groups and their corresponding relationships with respect to the system to develop. In general, the standard makes emphasis on the concept of human-centered rather than usercentered to stress the importance of stakeholders who may not be users [47]. In fact, some previous works agree with the importance of achieving a suitable requirements engineering in this human-centered standard in order to correlate quality attributes such as effectiveness, efficiency and satisfaction concerning the different stakeholders [48]. Other works have introduced the difficulty of specifying usability requirements in a testable form in this standard, as it is difficult to specify concrete metrics and criteria values early [49]. Other empirical studies corroborate existing differences among professionals, developers and users goals, denoting that professionals are more focused on emotion-related aspects, while users focus on context in terms of utility and degree of usage of the system to develop [50]. This way, a suitable prescription of requirements engineering activities is needed to correctly focus on each stakeholder's interests.

All in all, although ISO 9241-210 provides a suitable iterative model to develop e-Government applications, it is conceived as a descriptive model, thus it is necessary to adequately detail and prescribe the specific activities, tasks and products needed for e-Government development. This is, in fact, one of the main contributions of our approach that will be detailed in the following section.

In a nutshell, the analysis of the related work helped corroborate the first research question and hypothesis of our work, RQ_1 , which can be answered in the affirmative as most of the existing software development models are conceived from a technical perspective, lacking a prescription of specific activities to jointly address the identification and analysis of different stakeholders and the existing legislation as a source of requirements for the design of usable e-Government software applications.

3. The Proposed Approach

The main contribution of our approach is twofold. First, we have carried out a research on stakeholders to provide a characterization and further classification of roles and interests. Second, we have defined and prescribed different activities to be integrated into the proposed standard ISO 9241-210, taking advantage of the stakeholder classification to support specific tasks and create products to be managed by developers when building e-Government software applications. Features included highlight the importance of considering all stakeholders in the software development process, also considering existing regulations that define characteristics and functionality of the software, and a user-centered process to ensure usability overall.

3.1. Stakeholders Classification

Objectives in the implementation of e-Government applications greatly vary in every case and heavily depend on the context [16]. Thus, in addition to the variety of existing stakeholders, their interests can be often different and may conflict with one another [5].

Applying the classification created by Sharp et al. [51], it is possible to classify the stakeholders of an information system depending on their corresponding role:

- Users representing individuals, groups or companies that interact directly with the software or are affected by its use.
- Developers responsible for software development, installation and maintenance.
- Legislators acting as professional, governmental agencies, legal representatives, etc. They make rules or regulations, look after the compliance of them, and impact on the use or development of software.
- Decision-makers representing authorities, project managers, investors, etc. They are responsible for decisions that promote or encourage the development and use of software.

In addition, Rowley [32] proposed a specific number of stakeholders that can be involved in e-Government projects. Those are principally individuals, groups of individuals, or public and private organizations. Interestingly, an identification of two types of stakeholders, people as service users and people as citizens, is sated as they have different necessities in terms of services and information requested.

We have carried out a cross classification of stakeholders by bringing together the theories of Rowley and Sharp et al. The result is summarized in Table 1, where the first column depicts different groups of stakeholders that can be found in an e-Government environment [32], and the second column represents the role that each group of stakeholders can play in the development of an e-Government application [51]. By contrast, the third column includes the principal stakeholder benefits extracted from an analysis carried out with 15 e-Government experts in a meeting of the eGovMoNet [32], where each enrolled expert was asked to identify relevant benefits for each proposed e-Government stakeholder group appearing in the first column of Table 1. This way, the third column in Table 1 represents the top-rated stakeholder benefits. This study sheds light on the principal stakeholder benefits, where usability concerns are principally related to software-application users (service users and employees), whereas other technical stakeholders acting as developers, legislators or decision-makers are principally concerned with specific benefits such as project management, economic value, administrative burden, and so on.

The main idea behind the classification shown in Table 1 is to further identify stakeholder conflicts by relating the interests of a group of stakeholders with the goals of the others. For instance, in a G2C application citizens as users may be concerned with inspired confidence and security when introducing personal data in e-Government applications, but this may conflict with governmental agencies as decision-makers that are interested in integrating e-Government processes requesting to share personal user data. This way, interests of people as service users and as citizens in their role of users should be the objectives for ICT designers and developers, e-Government agencies and

politicians in their role of developers, decision makers and regulators, respectively. It is worth noting that the stakeholders' interests vary depending on the role they play in the development of e-Government applications. The relationship between stakeholders and the roles they can play, and how this affects their interests, may cause conflicts. On the other hand, this represents a feature of e-Government applications that needs to be addressed in a process model through specific activities, properly identifying interests and needs of each stakeholder through the underlying legislation. It also occurs in the degree of usability required by citizens as users when they access information and services, which may also conflict with the vision of ICT developers to fit the required development standards to ensure other quality attributes. Indeed, the interests of a stakeholder group should be the targets for others. For instance, in a user-centered development of a G2C application, the interests of citizens having the role of users should be the objectives to be met by government agencies having the role of decision-makers and by e-Government project managers and designers/ IT developers having the role of developers.

E-Government Stakeholders [32]	Stakeholder Categories [51]	Stakeholder Interests [32]			
People as Service Users and as Citizens	Users	Easy to use, Accessibility, Inclusivity, Confidentiality, Privacy, Openness and Inspired Confidence, User-Centered			
		Democracy			
Small, Medium and Large Size Enterprises	Users	Economic Growth Productivity, Value for Money, Resources Rationalization, Reduced Administrative Burden			
Public Administrators	Users	Easy to use, Continuity and Stability, Reduced Administrative Burden			
(employees)	Decision-Makers	Empowers Employees			
	Users	Reduced Administrative Burden			
Government Agencies	Decision-Makers	Integration among e-Government Units			
	Legislators	Standardization of Information and Services			
Non-Profit Organizations	Users	Openness and inspired Confidence, Accessibility, Inclusivity, Democracy			
	Users	Accountability			
Politicians	Decision-Makers	Democracy			
	Legislators	Openness and Inspired Confidence			
E-Government	Decision-Makers	Adoption of e-Government Projects			
Project Managers	Developers	Integration among e-Government Units, Interoperability of IT Systems			
Designers and IT Developers	Developers	Interoperability of IT Systems, Integration among e-Government Units, Standardization of Information and Services			
Suppliers and Partners	Users	Economic Growth, productivity, Interoperability of IT Systems, Openness and Inspired Confidence			
Researchers and	Users	Openness and Inspired Confidence,			

Table 1. Stakeholder interests according to different roles

According to that, we propose a strategy to classify each stakeholder intro three different groups:

- General Stakeholders. This category is useful to define the importance of general stakeholders in a given organization and so conveniently prioritize their requirements. Stakeholders can be divided into three different sub-categories depending on 3 attributes that they may have: power, legitimacy and urgency.
 - Latent: when the corresponding stakeholder has 1 out of the 3 mentioned attributes. This type of stakeholder has the lowest priority or importance in a given organization.
 - Expectant: when the corresponding stakeholder has 2 out of the 3 mentioned attributes. This type of stakeholder has medium priority or importance in a given organization and will be expectant to have the third attribute to upgrade priority.
 - O Definitive: when the corresponding stakeholder has 3 out of the 3 mentioned attributes. This type of stakeholder has the highest priority or importance in a given organization and has to be prioritized and addressed first.
- Information System Stakeholders. This category helps classify technical stakeholders depending on the role they have in the development of an Information System (IS), and so define corresponding tasks accordingly. Each IS stakeholder can be included in one of the following sub-categories:
 - o User: when the corresponding stakeholder directly interacts with the software or benefits from its results.
 - o Developer: when the corresponding stakeholder is responsible for the development of the system.
 - Legislator: when the corresponding stakeholder can make rules or legislation affecting the use or development of the software, or when s/he has to ensure compliance with the legislation.
 - Decision-Maker: when the corresponding stakeholder is responsible for making decision that promote or encourage the development and use of software.
- E-Government Stakeholders. This category is useful to initially identify the different stakeholder needs, analyzing possible conflicts that may exist with other stakeholders. The idea is to categorize and analyze stakeholders according to the classification proposed in Table 1, which specifies benefits and interests that each stakeholder expects to find in an e-Government application.

This classification strategy is used in the proposed process model, and it will be contextualized later on in the corresponding development activities.

3.2. Overview

We propose a set of activities prescribed for requirements engineering purposes. Such activities are mainly classified into two main activity groupings, which are: *Context of Use Understanding and Specification*, and *Requirements Cataloguing*. In addition, an

activity for *Product Quality Assurance* has been proposed. It is important to emphasize that the inclusion of the proposed activities does not imply to avoid others related to the development lifecycle of any software product, such as planning, design, coding, testing and operation activities. On the other hand, although there is no need to accomplish all the proposed activities in a given software project, the selected ones should be taken into account when planning and estimating the costs of a concrete e-Government project.

More specifically, the contributed activities are the following:

- Context of Use Understanding and Specification (Activity Grouping 1):
 - Activity 1.1. Stakeholder Identification. This activity is used to identify all the stakeholders that affect or are affected by the e-Government application. Stakeholder necessities and possible conflicts are identified.
 - o Activity 1.2. Existing Legislation Identification. This activity is used to identify legislation that affects the e-Government application development, defining main characteristic and constraints.
- Requirements Cataloguing (Activity Grouping 2):
 - O Activity 2.1. Stakeholder Analysis. This activity is intended to analyze the stakeholder necessities identified in Activity 1.1. This way, necessities are transformed into specific stakeholder requirements. This activity is focused on stakeholders that do not have the role of user in the system.
 - O Activity 2.2. User Analysis. This activity is used to analyze stakeholder necessities identified in Activity 1.1. In contrast to Activity 2.1, this one is focused on stakeholders having the role of user in the system. This way, necessities are transformed into user requirements, also with a view to educing usability requirements.
 - Activity 2.3. Legislation Analysis. This activity is focused on the analysis of legislation identified in Activity 1.2 in order to obtain specific organizational requirements.
 - o Activity 2.4. Final Requirements Cataloguing. This activity is used to gather all the requirements obtained from activities 2.1, 2.2 and 2.3 in order to prioritize them and resolve existing conflicts, thus generating the final validated SRS (Software Requirements Specification).
- Product Quality Assurance (independent activity):
 - O Activity 3.1. Legislation Requirements Inspection. In addition, an activity for product quality assurance has been defined in order to carry out traceability of legal requirements. This activity can be applied anytime when including, deleting and modifying legal requirements, which may cause inconsistencies with previous iterations of the process.

The execution of the different proposed activities is carried through the process inspired by ISO 9241-210. However, ISO 9241-210 comprises a descriptive model, it is thus necessary to detail the proposed activities, specifying important information for each one, such as specific tasks and techniques to carry out, input and output products, flow and activity interdependence, as well as the responsible roles for each activity accomplishment. The integration with the ISO process will be further detailed in Section 3.8.

3.3 Process Description

We have outlined our process according to the recommendations provided in ISO/IEC 12207/15288 – process constructs [12, 52]. This way, the contributed process comprises activities, detailed information about tasks, subtasks, responsible roles, generated products, interdependences and principal methods and techniques to use.

There are internal dependences upon the different activities and tasks according to the input and output products generated. As shown in Figure 1, activities included in grouping 1 can be executed in parallel as both activities focus their analysis on independent topics such as stakeholder identification (Activity 1.1) and relevant legislation identification (Activity 1.2). As for the activity grouping 2, there is a parallel execution of Activities 2.1 and 2.2 in order to analyze both general stakeholders and end-users, whereas there is a dependence on the execution of Activity 2.3, which has to be executed after Activity 1.2 in order to analyze information about legal requirements once laws and legislation have been previously identified. On the other hand, Activity 2.4 has to be performed when the others are completed, as this activity is used to deal with final software requirements. Finally, Activity 3.1 can be executed anytime, as it represents an inspection activity used to ensure product quality overall. As for the tasks, they are intended to split up activities intro smaller units and so generate corresponding products step by step. They have to be sequentially performed inside each activity they belong to.

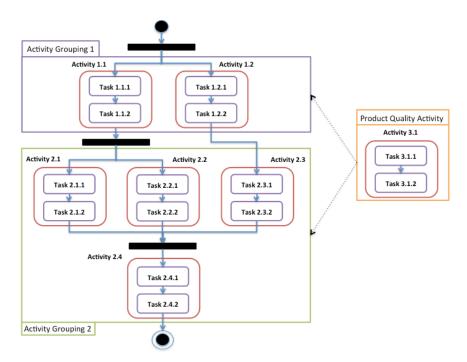


Fig. 1. Activity Diagram representing activity flow and interdependence, as well as the tasks included in each proposed activity

3.4. Suggested Methods and Techniques

In order to carry out the proposed activities and task, it is necessary to specify concrete

methods and techniques to obtain input products and transform them into output ones. This way, we propose different methods and techniques broadly used in Software Engineering and User-Centered Design that can be used by the development team to produce the corresponding products. Those are: unstructured interviews [43], field observations [42], surveys [53], ethnographic analysis [54], focus groups [55], conceptual maps [55], expert interviews [56], systematic mapping studies [7], scenarios [44], storyboards [42], UML modeling [57], paper prototypes [42] and conceptual task analysis [58]. We also propose different techniques used in the area of decision analysis such as decision trees [59] or influence diagrams [60]. Both can be used in early analysis tasks. Decision trees can be applied to evaluate different alternatives (interests and conflicts) when cataloguing diverse kinds of stakeholders. On the other hand, influence diagrams can be useful to evaluate the impact of legislation on the organization.

3.5. Products

In order to successfully achieve the proposed process model, it is necessary to specify products as input and output elements for each task. This way, our approach considers external input products (specified as E_i , i=1...N) that come outside the process and are necessary as input documents to execute each task. Also, intermediary and final products generated and consumed by the proposed tasks (specified as P_i , j=1...M) are necessary to carry through the process. In general, the product characteristics greatly depend on each specific activity. First activities generally generate small descriptive products as preliminary reports. However, advanced activities generate more detailed output documents, which are necessary for further analysis.

We propose 16 different products for the suggested process model in order to have broader documentation coverage and guarantee the successfulness of the objectives pursued. Both external and contributed products are described in Table 2.

Product ID	Description				
E ₁	General information about the stakeholders related with the system				
$E_{\scriptscriptstyle 2}$	General information about the hierarchical structure of all stakeholders				
	in the organization				
$\mathbf{E}_{\scriptscriptstyle 3}$	General information about the role that each stakeholder plays in the				
	information system				
E_{4}	General information about necessities and interests of each stakeholder				
\mathbf{E}_{s}	General information about legislation, regulations and specific laws				
	that can impact in the development of the system				
E ₆	Supplementary information on relevance and priority of each				
	stakeholder in the organization				
\mathbf{E}_{7}	General usability specifications reported by the information system's				
	users				
\mathbf{E}_{s}	Document containing new requirements to add, as well as proposed				
	removals and modifications to existing requirements				
$\mathbf{P}_{_{1}}$	Stakeholder requirements catalog				
P_2	User requirements catalog				

P_3	Functional legislation requirements catalog				
	C I				
P_4	Non-functional legislation requirements catalog				
\mathbf{P}_{5}	Usability requirements catalog				
$P_{\scriptscriptstyle 6}$	Final revised catalog of specific requirements				
\mathbf{P}_{7}	Traceability document				
P_{8}	Software Requirements Specification (SRS)				
P ₉	Report on requirements review				
P ₁₀	Report on stakeholder hierarchy				
\mathbf{P}_{11}	Preliminary report on stakeholder differentiation and cataloguing				
\mathbf{P}_{12}	Preliminary report on specific applicable legislation				
$\mathbf{P}_{\scriptscriptstyle{13}}$	Preliminary report on stakeholder interests				
P ₁₄	Preliminary report on the impact of the specific applicable legislation				
P ₁₅	Relationships document containing prioritized stakeholder interests and conflicts				
P ₁₆	Reasoned report on each prioritized stakeholder's interests and conflicts				

Table 2. Products Description

As shown in Table 2, external products (e.g., E₁, E₂, etc.) are more general and include descriptive information for initial analysis. On the other hand, preliminary and reasoned reports (e.g., P₃, P₁₀, P₁₁, etc.) include intermediate products that are necessary to supplement with specific information or achieve further analysis. In addition, catalog documents are involved in final activities related to requirements gathering (e.g., P₁, P₂, P₃, etc.). Finally, SRS (P₈) is the principal output involving the final validated requirements, and it will be used as an input for design activities.

Nevertheless, not all the products are strictly necessary and they can be shortened or avoided depending on the project. Although we cannot describe all the proposed products in detail for the sake of brevity, we have contextualized the products in each process task. Also, some brief instances can be found in Section 4, where a case study is presented. All in all, some of the products represent reports containing descriptive information or requirements catalogs. It is worth mentioning, however, two contributed products that are specific for the activities proposed. Those are the traceability document for requirements inspection and the stakeholder relationships document for prioritizing stakeholder interests and conflicts. These products are detailed in the next two sub-sections.

3.5.1. Traceability Document

This comprises the product P₇ in our approach, and it is generated in Activity 3.1 as an output product from the final revised requirements (P₆) and the SRS (P₈). As 3.1 is an activity for product quality assurance, P₇ is used to check that all the specific requirements are included in the final catalog, and also as a reference document for traceability when adding, removing or modifying requirements. Although the idea behind the traceability matrix has been already considered in Software Engineering as a quality-checking product, we have modified the original idea to check internal

requirements composition instead of traceability between requirements and functional units, which is the most widespread usage in the design stage. Figure 2 shows a brief product instance of the traceability document, where it is possible to confirm, for example, that final requirement FRQ-1 includes specific stakeholder requirements SR1.1 and SR1.2 as well as the user requirement UR1.2. This is represented by the symbol "X" in the corresponding cells.

P7 Traceability Document				
Author: Sánchez, E. And Macías J.A. Date: 05 August 2016 Version: 1.0				
		FRQ-1	FRQ-2	 FRQ-N
Stakeholders Requirements	SR1.1	х	х	
	SR1.2	х		
	SR1.3			
User Requirements	UR1.1			
	UR1.2	х		
	UR1.3			
Usability Requirements	UXR1.1		х	
	UXR1.2		х	
	UXR1.3		х	
Functional Legislation Requirements				
Non-Functional Legislation Requirements				

Fig. 2. Instance of P₇ - Traceability Document

3.5.2. Stakeholder Relationships Document

This product (P₁₅) is generated in Activity 1.1 from preliminaries reports on stakeholder differentiation (P₁₁), necessities and interests (P₁₃). This document graphically depicts, in a double-entry matrix, the relationships between the interests of different stakeholders. The aim is to analyze each stakeholder's interests, and detect whether there is a positive relationship or conflict with other identified stakeholder's interests, in order to produce a final report on positive relationships and conflicts (P16) to be later considered as a source of potential requirements. Figure 3 shows a brief product instance of this document, which comprises a matrix where the first row and column represent the stakeholders defined in document P₁₁. The second row and column correspond to the interests of each stakeholder identified in product P13. This way, each intersection identifies the relationship between the interests of each stakeholder considering different values for each cell: a null relationship represented by a blank cell; a positive relationship (interests are strengthened between the two stakeholders) represented by the symbol "+"; and a negative relationship (conflict of interest) represented by the symbol "-". For instance, in Figure 4 citizen stakeholder (ST1) having interest is confidentiality (ST1.1) may conflict with the government agency stakeholder (ST2) interested in integrating e-Government process requiring to share personal data (ST2.1). Therefore, the intersection between ST1.1 and ST2.1 is represented by the symbol "-".

P16 Stal	P16 Stakeholder Relationships Document								
Author: Sánchez, E. And Macías J.A. Date: 05 August 2016 Version: 1.0									
		ST1		ST2		ST3			
		ST1.1	ST1.2	ST2.1	ST2.2	ST2.3	ST3.1	ST3.2	
ST1	ST1.1								
	ST1.2	+							
ST2	ST2.1	-							
	ST2.2		+						
	ST2.3								
ST3	ST3.1	+							
	ST3.2								

Fig. 3. Instance of P₁₅ – Stakeholder Relationships Document

3.6. Quality Assurance

In order to ensure the product quality, we have considered different quality assurance mechanisms. Those are indicated in each activity's tasks. On the one hand, inspections [56, 61], reviews and formal technical reviews [62] are used to revise requirements. These mechanisms allow to identify conflicts and achieve traceability, also allowing to carry out a formal validation of the final requirements catalog by all stakeholders. Inspections and reviews are used in Activity 2.4, which is aimed at generating the final catalog of requirements, as well as in Activity 3.1, which comprises a product quality activity. On the other hand, Activity 3.1 is a product quality assurance activity aimed at accomplishing the traceability of legal requirements. This activity generates the product P₇, which is used to check that all specific requirements are included in the final catalog, even when adding, removing or modifying requirements in the next (process) iteration.

Additionally, different standard metrics can be considered to validate requirements by analyzing different quality attributes such as unambiguity, completeness, correctness, understandability, verifiability, internal and external consistency, and so on [63, 64, 65]. These metrics are especially useful in Activity 2.4 (Tasks 2.4.1 and 2.4.2), which is in charge of the final requirements cataloguing, and where quality assurance mechanisms take place to inspect and formally review the SRS.

In addition, a contributed metric is calculated using P_7 in Activity 3.1 – Task 3.1.1 (Traceability of Legislation Requirements). Such a metric, namely *CoveredRequirement*, is used to measure the traceability quality attribute in terms of the coverage of each requirement. More specifically, it helps detect that every single stakeholder, user, usability, functional or non-functional legislation requirement is included in, at least, one of the final requirements, indicating a quality failure when this condition is not fulfilled (*CoveredRequirement(Requirement_i)* = 0). This metric can be defined as:

$$CoveredRequirement(Requirement_i) = \begin{cases} 1, & \text{if } \exists j : FinalRequirement_{i,j} = "X" \\ 0, & \text{otherwise.} \end{cases}$$
 (1)

Where $Requirement_i$ represents any (stakeholder, user, usability, functional or non-functional legislation) requirement. For instance, when i=1 this corresponds to stakeholder requirement SR1.1 in Figure 2. On the other hand, $FinalRequirement_{i,j}$ represents any final requirement j associated to $Requirement_i$. For instance, when i=1 and j=1 this corresponds to the intersection of SR1.1 and FRQ-1 in Figure 2, where a "X" appears to indicate that stakeholder requirement SR1.1 is included in final requirement FRQ-1. This metric can be useful when applying the proposed quality assurance mechanisms – i.e., inspections and reviews.

3.7. Activity Prescription

To carry on with the approach, we present down below the prescription of each one of the activities shown in Figure 1, including detailed information about tasks, subtasks, responsible roles, generated products, interdependences and principal methods and techniques to use.

3.7.1. Activity 1.1. Stakeholder Identification

The main objective of this activity is to identify all the stakeholders, determining their characteristics, necessities and joint interests.

Task 1.1.1. Stakeholder Identification

- Description: this task is focused on identifying involved stakeholders and classifying them into three different categories according to the method described in Section 3.1 (i.e., General Stakeholders, IS Stakeholders and e-Government Stakeholders). To carry out this task, it is necessary to take into consideration external information about the stakeholders (E₁), their hierarchical structure (E₂) and the role they play in in the information system (E₃). As a result, a document identifying all the stakeholders is produced (P₁₁).
- Suggested methods and techniques: unstructured interviews, field observations, surveys and ethnographic analysis.
- Involved roles: project manager and requirements engineer.
- Input products:
 - O Stakeholders to consider (E₁).
 - o Hierarchy of stakeholders in the organization (E₂).
 - \circ Role of stakeholders in the information system (E₃).
- Output product:
 - o Preliminary report on stakeholder differentiation and cataloguing (P₁₁).
 - Destination: Tasks 1.1.2, 2.1.1, 2.1.2, 2.2.1 and 2.2.2.

Task 1.1.2. Stakeholder Analysis on Objectives, Interests and Conflicts

- Description: this task is used to analyze the different stakeholders previously identified, highlighting objectives, necessities, interests and possible conflicts. To do so, product P₁₁, generated in the previous task, is taken into consideration

together with external product E_4 including information collected from different interviews and other information gathering techniques. The most important output product in this task is P_{16} , which will be used to transform objectives and interest into requirements later on.

- Suggested methods and techniques: unstructured interviews, focus groups and conceptual maps.
- Involved roles: project manager and requirements engineer.
- Detailed procedure:
 - O Sub-task 1.1.2.1. Identify and characterize necessities and interests of each stakeholder individually (this generates P₁₈).
 - O Sub-task 1.1.2.2. Analyze each stakeholder's interests to detect joint conflicts of interests (this generates P₁₅).
 - o Sub-task 1.1.2.3. Enumerate and prioritize interests and conflicts of all stakeholders (this generates P₁₆).
- Input products:
 - O Necessities and interest of each stakeholder (E₄).
 - \circ Preliminary report on stakeholder differentiation and cataloguing (P_{ii}) from Task 1.1.1.
- Output products:
 - O Preliminary report on each stakeholder's interests (P₁₃).
 - Destination: Tasks 2.1.2, 2.2.1 and 2.2.2.
 - O Stakeholder relationships document double entry matrix representing each prioritized stakeholder's interests and conflicts (P₁₅).
 - Destination: Tasks 2.1.2, 2.2.1 and 2.2.2.
 - Reasoned report on each prioritized stakeholder's interests and conflicts (P_{16}) .
 - Destination: Tasks 2.1.2, 2.2.1 and 2.2.2.

3.7.2. Activity 1.2. Existing Legislation Identification

The main objective of this activity is to identify problem-domain legislation and regulations, analyzing the impact in the definition of restrictions and required functionality.

Task 1.2.1. Identification of Relevant Legislation

- Description: this task is aimed at identifying legislation and specific laws that can be relevant for the development of the system. This is carried out by using external information (E_s) coming from existing legislation reviews and interviews, thus generating product P₁₂ used later on to refer specific legislation.
- Suggested methods and techniques: expert interviews and systematic mapping studies.
- Involved roles: project manager, requirements engineer, and lawyer or legislation expert.
- Input product:
 - Legislation, regulations and specific laws that can impact in the development of the system (E_s).
- Output product:

- o Preliminary report on specific applicable legislation (P₁₂).
 - Destination: Tasks 1.2.2, 2.3.1, 2.3.2 and 2.4.1.

Task 1.2.2. Analysis on Impact of Specific Legislation

- Description: this task is aimed at analyzing the impact of the legislation previously identified and related to the system to develop, determining whether such legislation affects specific functionalities, adds restrictions or determines the system's parameters. Product P₁₂, previously generated, is used as input information, thus generating P₁₄ as output document.
- Suggested methods and techniques: expert interviews and systematic mapping studies.
- Involved roles: project manager, requirements engineer, and lawyer or legislation expert.
- Input product:
 - o Preliminary report on specific applicable legislation (P₁₂) from Task 1.2.1.
- Output product:
 - O Preliminary report on the impact of the specific applicable legislation (P_{14}) .
 - Destination: Tasks 2.3.1 and 2.3.2.

3.7.3. Activity 2.1. Stakeholder Analysis

This activity is responsible for analyzing each stakeholder's necessities and interests to obtain specific stakeholder requirements. It is worth noting that this activity is focused on stakeholders that do not have the role of user, according to the categories defined in Section 3.1 with respect to IS Stakeholders.

Task 2.1.1. Analysis on Stakeholder Role and Impact

- Description: this task is aimed at analyzing the role assumed by each stakeholder, as well as the impact that this represents in the system to develop, defining importance and priority for each stakeholder. To carry out this task, it is necessary to investigate stakeholders in their real environment. This way, external product E₆ is necessary and has to be created using field observations carried out by experts, rather than considering subjective information. As a result, this task generates a sorted stakeholders list according to their hierarchy and importance, represented by product P₁₀.
- Suggested methods and techniques: unstructured interviews and field observations.
- Involved roles: requirements engineer and functional analyst.
- Input products:
 - O Supplementary information on relevance and priority of each stakeholder in the organization (E_{\circ}).
 - \circ Preliminary report on stakeholder differentiation and cataloguing (P_{11}) from Task 1.1.1.
- Output product:
 - O Report on Stakeholder Hierarchy (P₁₀).

Destination: Tasks 2.4.1 and 2.4.2.

Task 2.1.2. Analysis on Stakeholder Requirements

- Description: this task is aimed at identifying and analyzing stakeholder requirements, transforming necessities, interests and previously identified objectives into specific requirements. This task is focused on stakeholders having no role of user (see Section 3.1). To carry out this task, several input documents are needed to product P₁ used to catalog all the requirements.
- Suggested methods and techniques: scenarios, storyboards and use case diagrams.
- Involved roles: requirements engineer and functional analyst.
- Input products:
 - o Preliminary report on stakeholder differentiation and cataloguing (P₁₁) from Task 1.1.1.
 - o Preliminary report on each stakeholder's interests (P_B) from Task 1.1.2.
 - O Stakeholder relationships document double entry matrix representing each prioritized stakeholder's interests and conflicts (P₁₅) from Task 1.1.2.
 - O Reasoned report on each prioritized stakeholder's interests and conflicts (P_{16}) from Task 1.1.2.
- Output product:
 - O Stakeholder requirements catalog (P₁).
 - Destination: Task 2.4.1.

3.7.4. Activity 2.2. User Analysis

This activity is focused on analyzing stakeholders having the role of user, according to the categories defined in Section 3.1 with respect to IS Stakeholders. The main objective is to transform the user's interests and necessities into functional and usability requirements.

Task 2.2.1. Analysis on User Functional Requirements

- Description: This task is aimed at analyzing user functional requirements, according to interests, necessities and objectives identified in previous tasks. To carry out this task, it is necessary to take into consideration only user information and requirements coming from previous generated documents, in order to generate P₂ comprising the user requirements catalog.
- Suggested methods and techniques: scenarios, use case diagrams and conceptual task analysis.
- Involved roles: requirements engineer and functional analysts.
- Input products:
 - Preliminary report on stakeholder differentiation and cataloguing (P₁₁) from Task 1.1.1.
 - O Preliminary report on each stakeholder's interests (P_B) from Task 1.1.2.
 - O Stakeholder relationships document double entry matrix representing each prioritized stakeholder's interests and conflicts (P₁₅) from Task 1.1.2.

- Reasoned report on each prioritized stakeholder's interests and conflicts (P_{16}) from Task 1.1.2.
- Output product:
 - O User requirements catalog (P₂).
 - Destination: Tasks 2.2.2 and 2.4.1.

Task 2.2.2. Analysis on Usability Requirements

- Description: this task is aimed at analyzing usability requirements. Users actively participate in this task, as it represents the main source of usability requirements. To carry out this task, it is necessary to obtain external usability specifications (E₇) using different techniques, as well as other yet-generated documents to finally obtain the usability requirements catalog represented by output product P₅.
- Suggested methods and techniques: storyboards, paper and other low-fidelity prototypes.
- Involved roles: requirements engineer, usability engineer and functional analyst.
- Input products:
 - O Usability specifications reported by users (E_7) .
 - O User requirements catalog (P₂) from Task 2.2.1.
 - o Preliminary report on stakeholder differentiation and cataloguing (P₁₁) from Task 1.1.1.
 - o Preliminary report on each stakeholder's interests (P₁₃) from Task 1.1.2.
 - O Stakeholder relationships document double entry matrix representing each prioritized stakeholder's interests and conflicts (P₁₅) from Task 1.1.2.
 - Reasoned report on each prioritized stakeholder's interests and conflicts (P_{16}) from Task 1.1.2.
- Output product:
 - O Usability requirements catalog (P_s).
 - Destination: Task 2.4.1.

3.7.5. Activity 2.3. Legislation Analysis

This activity is focused on determining characteristics, functionalities and restrictions motivated by specific legislation, in order to obtain corresponding organizational requirements.

Task 2.3.1. Analysis on Legislation Defining Functional Requirements

- Description: this task is aimed at analyzing relevant legislation to define corresponding system functionalities that will be transformed into functional requirements. To carry out this task, it is necessary to process previous information related to legislation and how it impacts in the organization (P₁₂ and P₁₃), generating output product P₃ including the corresponding functional requirements catalog. This output information is important to analyze existing conflicts and validate stakeholder and user requirements against legislation requirements later on.
- Suggested methods and techniques: scenarios, decision trees and influence

- diagrams.
- Involved roles: requirements engineer, functional analyst and lawyer or legislation expert.
- Input products:
 - Preliminary report on specific applicable legislation (P₁₂) from Task
 1 2 1
 - O Preliminary report on the impact of the specific applicable legislation (P_{14}) from Task 1.2.2.
- Output product:
 - o Functional legislation requirements catalog (P₃).
 - Destination: Task 2.4.1 and 3.1.2.

Task 2.3.2. Analysis on Legislation Defining Non-Functional Requirements

- Description: this task is aimed at analyzing relevant legislation from previous reports (P₁₂ and P₁₄) in order to define restrictions, parameters and system scope. To carry out this task, it is necessary to take into consideration different parameters and restrictions defined by legislation. This may imply the identification of specific technological platforms, resources restrictions, security and privacy policies and, in general, any characteristic not directly related to functionality but defined by existing legislation. This information is included in output document P₄. This output information is important to analyze existing conflicts and validate stakeholder and user requirements against legislation requirements later on.
- Suggested methods and techniques: scenarios, decision trees and influence diagrams.
- Involved roles: requirements engineer, functional analyst and lawyer or legislation expert.
- Input products:
 - o Preliminary report on specific applicable legislation (P₁₂) from Task 1.2.1.
 - O Preliminary report on the impact of the specific applicable legislation (P_{14}) from Task 1.2.2.
- Output product:
 - o Non-functional legislation requirements catalog (P₄).
 - Destination: Task 2.4.1 and 3.1.2.

3.7.6. Activity 2.4. Final Requirements Cataloguing

This activity is focused on identifying possible conflicts existing between user, stakeholder and legislation requirements, in order to generate the final requirements catalog.

Task 2.4.1. Analysis and Resolution of Requirements in Conflict

Description: this task is focused on analyzing relationships in previous generated information (P₁, P₂, P₃, P₄, P₅, P₁₀ and P₁₂), identifying possible conflicts and positive relationships. To carry out this task, it is necessary to analyze stakeholder, user, usability and legislation requirements jointly in order to

identify possible conflicts. The result is the output product P₆, which should not include any conflicting requirement. The criteria to solve possible conflicts is as follows:

- Functional and non-functional legislation requirements take precedence over others, as the e-Government application should strictly obey the legislation. Therefore, the other requirements should be discarded or modified accordingly.
- o When a conflict exists between stakeholder and user requirements, the hierarchy precedence should be observed according to the input product P₁₀. Therefore, the other requirements should be discarded or modified accordingly.
- Quality assurance mechanisms: inspections and reviews.
- Involved roles: requirement engineer and functional analyst.
- Input products:
 - Stakeholder requirements catalog (P₁) from Task 2.1.2.
 - O User requirements catalog (P₂) from Task 2.2.1.
 - o Functional legislation requirements catalog (P₃) from Task 2.3.1.
 - o Non-functional legislation requirements catalog (P₄) from Task 2.3.2.
 - O Usability requirements catalog (P_s) from Task 2.2.2.
 - o Report on Stakeholder Hierarchy (P₁₀) from Task 2.1.1.
 - o Preliminary report on specific applicable legislation (P₁₂) from Task 1.2.1.
- Output product:
 - o Final revised catalog of specific requirements (P₀).
 - Destination: Tasks 2.4.2 and 3.1.1.

Task 2.4.2. Validation, Prioritization and Generation of Final Requirements

- Description: this task is aimed at validating and organizing requirements according to organizational priority, stakeholder hierarchy and resource restrictions. To carry out this task, it is necessary that all specific stakeholders (i.e., users, decision-makers and legislators) participate in the validation of all requirements that will be included in the SRS output product P_s after a formal technical review. Requirements will be prioritized considering the following criteria:
 - Legislation requirements have the highest priority, as the e-Government application must strictly obey the legislation.
 - The rest of requirements will be prioritized according to their hierarchical precedence by considering the input product P₁₀.
- Quality assurance mechanisms: formal technical reviews.
- Involved roles: requirements engineer, functional analyst and specific stakeholders: users, decision-makers and legislators.
- Detailed procedure:
 - Sub-task 2.4.2.1. Validation of the requirements defined in products P₆. This involves stakeholders with decision-maker and legislator roles, who participated in the software solution, as well as stakeholders with user role, who must participate in the validation of user and usability requirements.

- o Sub-task 2.4.2.2. Prioritization of validated requirements considering the stakeholder hierarchy defined in product P₁₀, also considering possible organizational priorities and restrictions on existing resources.
- o Sub-task 2.4.2.3. Definition of specific software requirements and generation of the final SRS (product P_s).
- Input products:
 - o Final revised catalog of specific requirements (P₆) from task 2.4.1.
 - o Report on Stakeholder Hierarchy (P₁₀) from task 2.1.1.
- Output product:
 - O Software Requirements Specification (P₈).
 - Destination: Tasks 3.1.1, 3.1.2 and design activity grouping.

3.7.7. Activity 3.1. Legislation Requirements Inspection

This is a quality activity aimed at inspecting and reviewing legislation requirements along the iteration process as general consistency may be altered when removing, modifying or adding new legislation requirements. This way, this activity is necessary in order to inspect and preserve quality issues over legislation requirements that cannot be modified or removed, also analyzing new requirements to be included that may conflict with existing ones. This activity can be executed in parallel with the other activities when necessary.

Task 3.1.1. Traceability of Legislation Requirements

- Description: this task is aimed at accomplishing a traceability of requirements in order to verify completeness and consistency with the existing legislation requirements. To carry out this task, a traceability matrix has to be created (P_7) from the final revised catalog of specific requirements (P_8) and the SRS (P_8) .
- Quality assurance mechanisms: inspections and reviews.
- Involved roles: requirements engineer, quality analyst and auditor.
- Input products:
 - o Final revised catalog of specific requirements (P₆) from Task 2.4.1.
 - o Software Requirements Specification (P_s) from Task 2.4.2.
- Output product:
 - O Traceability Document (P₇).
 - Destination: Task 3.1.2.

Task 3.1.2. Revision of Legislation Requirements

- Description: this task is aimed at detecting possible conflicts with existing legislation requirements whenever a requirement is modified, removed or added (E_s). To do so, the legislation requirements catalog (P₃ and P₄), the SRS (P₈) and the traceability document is used (P₇) This way, all the final documents concerning legislation requirements should be updated according to the information stated in the output product (P₉). Conflicts should be analyzed and corrected with support of quality assurance staff and other domain professionals.
- Quality assurance mechanisms: reviews.
- Involved roles: requirements engineer, quality analyst, auditor and lawyer or legislation expert.

- Input products:
 - New requirements or proposed modifications and removals (E_s).
 - o Functional legislation requirements catalog (P₃) from Task 2.3.1.
 - o Non-functional legislation requirements catalog (P₄) from Task 2.3.2.
 - o Traceability document (P_7) from Task 3.1.1.
 - o Software Requirements Specification (P_s) from Task 2.4.2.
- Output product:
 - O Report on requirements review (P₉).
 - Destination: Quality Assurance.

3.8. Integration with ISO 9241-210

Figure 4 depicts the main activity groupings defined in ISO 9241-210 – the standard for ergonomics of human-computer interaction, represented by numbered rectangles from 1 to 4. As justified in Section 2.3, ISO 9241-210 represents a suitable framework to integrate the proposed activities for the usable development of e-Government application. The standard does not include specific tasks for each activity grouping, but principles and recommendations such as the following [6]:

- The development is based on an explicit understanding of users, tasks and environments, taking into account the people who will use the software as well as other stakeholder groups (e.g., different stakeholders in an e-Government application).
- Users are involved throughout development, providing an important source of knowledge about the context of use.
- The development is driven and refined by user-centered evaluation, exploiting user feedback to progressively refine the final product.
- The process is iterative, avoiding uncertainty and minimizing the risk of failing to meet user requirements.
- The development addresses the whole user experience, going beyond the mere concept of ease of use.
- The development team includes multidisciplinary skills and perspectives, taking advantage of the knowledge from other disciplines (e.g., legislation experts).

As shown in Figure 4, we have integrated the prescribed activities into the requirements engineering activity groupings defined in ISO 9241-210. Those groupings correspond to: 1. Understand and Specify Context of Use, and 2. Specify User Requirements. On the one hand, Understand and Specify Context of Use activity grouping is aimed at obtaining the context of use description, whereas Specify User Requirements activity grouping is aimed at obtaining the context of use specification, a description of the user's needs and the user requirements specification. Besides, the contributed activity for product quality is not related to any specific ISO activity grouping but considered along the whole process as a quality assurance activity.

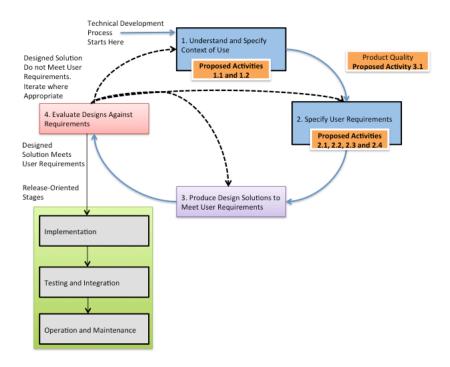


Fig. 4. Iterative Process Model Inspired by ISO 9241-210

The process suggested by ISO 9241-210 is mostly iterative, being activity grouping 4 the breaking point for the next iteration. Once the proposed design has been accepted, the following technical activity groupings (from implementation onwards) take place.

The integration of the contributed activities into the ISO process is straightforward, as activity groupings 1 and 2 are carried out sequentially (see activity diagram in Figure 1). This way, it is necessary to carry out context specification activities before gathering the corresponding requirements. This, way, contributed activities 1.1 and 1.2 can be directly integrated into activity grouping 1 (Understand and Specify Context of Use), whereas contributed activities 2.1, 2.2, 2.3 and 2.4 can be integrated into activity grouping 2 (Specify User Requirements), as deployed in Figure 4. This fits well as the objective of the activities included in activity grouping 1 is to carry out a contextual study, identifying the environment in which the e-Government solution will be implemented. This group of activities is aimed at identifying the technological, social and organizational characteristics that may affect the development, as well as identifying existing legislation that may rule the system. On the other hand, activities included in activity grouping 2 are focused on analyzing and cataloguing requirements based on the information identified in previous activities. Finally, Activity 3.1 is aimed to inspect and review legal requirements throughout the process. This is mainly due to the iterative nature of the selected model, where requirements set may change during the process by adding, modifying or deleting new requirements. Therefore, it is necessary to detect legal requirements that cannot be modified or deleted, as well as to identify new requirements that can be in conflict with the existing ones.

As commented before, the inclusion of the proposed activities does not imply to avoid others related to the development lifecycle that can be also included into the ISO standard. All in all, the ISO is only a reference framework to encourage the utilization

of user-centered activities, and those contributed in this paper can be used along with other activities required by developers. In fact, there is no need to accomplish all the proposed activities, as this mostly depends on the project's characteristics. From a practical point of view, the contributed activities can be combined with other requirements engineering, design and evaluation activities on demand under the ISO framework.

The prescription of the different requirements engineering activities, and the integration into a iterative user-centered process inspired by ISO 9241-210 helped corroborate the second research question and hypothesis of our work, RQ_2 , which can be answered in the affirmative as it is possible to propose specific software development activities and techniques, and integrate them into a user-centered development model, with the aim of producing usable e-Government applications. In addition, this can be done by considering usability issues, identifying and analyzing the stakeholders' main interests and conflicts, and including existing legislation as a source of requirements.

4. Validation through a Case Study

We have applied the aforementioned process in different scenarios. Nevertheless, and due to space limitation and sake of brevity, we propose here a validation through a brief scenario involving the activities presented in Section 3 for the development of an e-Government web application. This way, we present in this section a selection of the products involved in the execution of representative tasks, which can give an idea of the adequacy of the activities designed for the intended purpose and further support the initial hypothesis related to RQ_2 .

4.1. The Case Study

We propose an e-Government solution based on a web application enabling any citizen in the Republic of Chile to start her/his own business, including main processes of company creation, modification and dissolution.

The creation of a company in the Republic of Chile is a complex process regulated by law, where stakeholders have to accomplish several procedures involving different governmental agencies. This way, there exist different stakeholders that may impact in the development of this application. Moreover, implementation must fulfill Law 20.659 and the requirements stated in Law Decree 45, related to electronic registry of companies and business associations, and the way legal citizens can access to the creation, modification and dissolution of commercial companies, respectively.

On the other hand, the Chile Ministry of Economy can be considered as the principal stakeholder interested in the business success. Therefore, according to the information depicted in Table 1, this institution has the role of government agency. Similarly, there are other stakeholders such as citizens having the role of people as service users and as citizens, and interested companies having the role of small, medium and large size enterprises. Besides, the participation of other stakeholders is also required, as the Register of Commerce having the role of other government agencies, and notaries having the role of small, medium and large size enterprises, are also involved.

4.2. Process Execution

In order to obtain the principal products, activities and tasks prescribed in Section 3 were applied. The proposed activity arrangement will be followed for a more structured presentation of results. Activity 3.1 was also executed in order to analyze the changing requirements and its impact on the development process. For the sake of brevity, only some examples of the products generated will be described below.

To start with, Activity 1.1 provided a set of intermediate products (P_{11} , P_{13} and P_{15}) in order to identify and analyze the different stakeholders, as a result of the "Understand and Specify Context of Use" stage in the proposed model. Therefore, the principal output from this activity is document P_{16} . But first, the different stakeholders were identified (P_{11}):

- ST1 Ministry of Economy
 - General Stakeholder classification: Definitive.
 - Information System Stakeholder classification: Users, Developers, Legislators and Decision-Makers.
 - E-Government Stakeholder classification: Government Agencies.
- ST2 Tax Agency
 - o General Stakeholder classification: Expectant.
 - Information System Stakeholder classification: Users.
 - E-Government Stakeholder classification: Government Agencies.
- ST3 Civil Registry
 - o General Stakeholder classification: Expectant.
 - o Information System Stakeholder classification: Users.
 - o E-Government Stakeholder classification: Government Agencies.
- ST4 Government Gazette
 - o General Stakeholder classification: Expectant.
 - o Information System Stakeholder classification: Users.
 - o E-Government Stakeholder classification: Government Agencies.
- ST5 Notary
 - o General Stakeholder classification: Expectant.
 - Information System Stakeholder classification: Users.
 - o E-Government Stakeholder classification: Small, Medium and Large Size Enterprises.
- ST6 Legal Entity
 - o General Stakeholder classification: Definitive.
 - o Information System Stakeholder classification: Users.
 - o E-Government Stakeholder classification: Small, Medium and Large Size Enterprises.
- ST7 Person
 - o General Stakeholder classification: Definitive.
 - o Information System Stakeholder classification: Users.
 - o E-Government Stakeholder classification: People as Service Users and as Citizens.

In order to create P_{16} , it was necessary to analyze objectives, interests and conflicts of each stakeholder (by first considering products P_{11} and P_{12}). This enabled to elaborate product P_{13} including the stakeholder relationship matrix (an example is shown in Figure 3). For instance, in the case of stakeholder ST1 – Ministry of Economy, we have the following preliminary information on stakeholder interests reflected in product P_{13} :

- ST1.1. Information System Stakeholder classification: Legislators. Comply with the existing legislation.
- ST1.2. Information System stakeholder classification: Legislators. Standardize process and documents for organization registry.
- ST1.3. Information System stakeholder classification: Developers and Decision-Makers. Meet existing deadlines.

- ST1.4. Information System stakeholder classification: Developers and Decision-Makers. Integrate the organization registry in other governmental agencies.
- ST1.5. Information System stakeholder classification: Users. Reduce administrative burden.

Once created and analyzed P_{15} , there were interest conflicts that needed to be solved or minimized to finally obtain P_{16} (reasoned report on each prioritized stakeholder's interests and conflicts). An example extracted from P_{16} for the case of the previous described ST1.1, is the following:

- ST1.1 Comply with the existing legislation
 - o Stakeholder: Ministry of Economy.
 - General Stakeholder classification: Definitive.
 - o Information System stakeholder classification: Legislators.
 - Positive relationships:
 - ST1.3. Meet existing deadlines. Such deadlines will be defined by law.
 - o Negative relationships (conflicts):
 - ST1.5, ST2.1, ST3.1, ST4.1, ST5.1, ST6.3 (reduce administrative burden). Strict compliance with the law may require users to carry out tasks that they do not consider as necessary, increasing the administrative burden.
 - ST6.5, ST7.1 (ease of use). Strict compliance with the law may require users to carry out complex and unfamiliar tasks, which could increase the difficulty in using the software.

In addition, Activity 1.2 was executed in order to identify and analyze required legislation. This way, a preliminary report on specific applicable legislation was created (P_{12}) , as well as a document on the impact of such legislation (P_{14}) . For the proposed case study, the following legislation was identified and analyzed (P_{14}) :

- L1 Law 20.659.
 - Description: Main features of electronic registry for the creation, modification and dissolution of commercial companies.
 - Legislation type: National.
 - o In force since: 02 May 2013.
 - Nature: Compulsory.
- L2 Law Decree 45
 - Description: Adoption of Law 20.659, defining main features of electronic registry for the creation, modification and dissolution of commercial companies.
 - Legislation type: National.
 - o In force since: 02 May 2013.
 - Nature: Compulsory.
- L3 Law 19.857
 - Description: Characteristics and requirements for the establishment of individual limited liability companies.
 - Legislation type: National.
 - o In force since: 11 February 2003.
 - Nature: Compulsory.
- L4 Law 3.918
 - Description: Characteristics and requirements for the establishment of civil and commercial companies with limited liability of members.
 - Legislation type: National.
 - o In force since: 11 April 1997.
 - Nature: Compulsory.
- L5 Law 18.046
 - o Description: Characteristics and requirements for the establishment of corporations.
 - Legislation type: National.
 - o In force since: 01 February 2012.
 - o Nature: Compulsory.

- L6 Law 20.179
 - Description: Characteristics and requirements for the establishment of mutual guarantee societies
 - o Legislation type: National.
 - o In force since: 02 June 2007.
 - o Nature: Compulsory.
- L7 Commerce Code
 - Description: Characteristics and requirements for the establishment of commercial companies and limited partnerships.
 - o Level: National.
 - o In force since: 01 January 2011.
 - o Nature: Compulsory.

Considering the output from Activity 1.1, activities included in the "Specify User Requirements" process stage are executed. This way, Activity 2.1 was achieved in order to carry out a stakeholder analysis by analyzing the role and impact of each stakeholder, producing P_{10} to analyze each stakeholder's interests and conflicts to obtain the stakeholder requirements catalog (P_1). Similarly, Activity 2.2 was also achieved to carry out a user analysis and obtain main product P_2 including the user requirements catalog, and P_3 including the usability requirements catalog. The following are examples of usability requirements extracted from P_3 :

- UXR1.7 Information about the process progress
 - Description: Display a progress bar showing the progress degree for any process, detailing the number of steps taken and the remaining number of steps.
 - Involved Stakeholders: ST7 Person classified as Users.
- UXR7.2 Navigation Map
 - o Description: Show a navigation map with all the navigation options available.
 - Involved Stakeholders: ST7 Person classified as Users.

In a similar way, Activity 2.3 was executed to carry out a legislation analysis and thus obtain the functional (product P_3) and non-functional (Product P_4) legislation requirements. The following are examples of functional legislation requirements extracted from P_4 :

- FLR2.11 Electronic Sign
 - Description: Recordable documents must be signed by advanced electronic signature or notarized.
 - o Involved Legislation: L2 Article 12.
- FLR7.2 Compulsory Data for Commercial Companies
 - Description: It will be compulsory for Commercial Companies to introduce all data in creation, modification and dissolution processes.
 - o Involved Legislation: L7.

Finally, Activity 2.4 was achieved to have a revised catalog of specific requirements (product P_{s}) and, after a validation, the final SRS – Software Requirements Specification (P_{s}) was obtained and later on used to carry on with the development process.

As different stakeholders and governmental agencies are involved, it was necessary to add, update and modify requirements along process. Therefore, it was required to assess possible conflicts that may exist with the existing legislation requirements. To carry out this task, Activity 3.1 was achieved in order to inspect the requirements traceability by means of product P_7 (an example is shown in Figure 2) and report a review of requirements (product P_9). Furthermore, the metric *CoveredRequirement* was used to

ensure the traceability of legislation requirements, obtaining a compressive coverage in all cases ($CoveredRequirement(Requirement_i) = 1, \forall i = 1..N$).

4.3. Further Validation and CASE Support

The presented case study helped show the process execution and the most relevant products generated through the proposed activities. Although the case study is based on the legislation of a specific county, the contributed process supports the inclusion of different legislators and legislations that can be properly analyzed and elicited according to the activities proposed in the process, involving also the quality assurance activity to detect conflicts. On the other hand, validation can be also complemented using any of the existing solutions that may help to manage the requirements engineering [66]. Concretely, we have not used any specific tool to assist developers with the whole process. However, we have partially used a CASE (Computer-Aided Software Engineering) solution, called ReqMan® [67], to help with activities concerning information gathering, requirements cataloguing and validation. ReqMan® provides support for requirements elicitation, verification and validation [66], including notable functionalities to work in a distributed environment, thus facilitating the participation of different stakeholders. The tool also features the automatic extraction and comparison of requirements from different documents. Such functionalities are specifically useful for our approach, considering the number of existing products managed and generated by different stakeholders. Comparison and traceability features also facilitate the identification of conflicts in legislation requirements through the quality assurance Activity 3.1. Also, the tool facilitates the active participation of all stakeholders in inspections and revisions, generating output for other well-known tools such as IBM Doors, Polarion, and so on [66].

5. Conclusion

E-Government applications significantly differ from other software solutions, as specific issues including stakeholders and legislation should be broadly considered. For a long time, functionality-based development has been considered as the main target for most development project, underestimating usability issues and other stakeholder interests [68]. This paper is focused on such concern, providing the basis of stakeholder and legislation analysis to carry out e-Government application development through a user-centered approach. To carry out this task, this paper analyzes the special characteristics of an e-Government environment, emphasizing in its implementation where different stakeholders with conflict of interests exist, and where different legislation affects the functionality and final requirements of the application.

More precisely, the main contribution of this paper is twofold. First, we have carried out a research on stakeholders to provide a characterization and further classification of roles and interests. Then, we have proposed the prescription of 6 activities focused on in-depth analysis of stakeholders, usability and legislation, as well as requirements elicitation, and 1 activity focused on product quality assurance. For each activity, objectives and concrete implementation aspects were detailed, defining a total of 14 specific tasks and including a total of 16 input and output products, all exclusively focused on obtaining successful requirements to develop web-based e-Government applications considering usability overall. To carry out this challenge, we propose the

descriptive ISO 9241-210 as a frame of reference to work in an iterative user-centered process and deal with different stakeholders and organizational requirements to address reference legislation.

Our research is based on two research questions, RQ_1 and $RQ2_2$. To answer $RQ1_1$ we have analyzed existing literature, and we found that no specific solutions exist and that the existing development processes do not contemplate stakeholders, legislation and usability jointly as a source of requirements in the development of e-Government applications. To answer $RQ2_2$, we have proposed a set of specific activities and techniques to face the drawbacks mentioned in $RQ1_1$ and thus improve the development of e-Government solutions. In addition, a validation of the proposed development model was carried out through a case study related to the analysis of an e-Government web application for the electronic registry of companies and corporations in a specific country.

All in all, our research is an attempt to bridge the gap between Software Engineering and Human-Computer Interaction [69, 70], providing activity prescriptions and specific techniques to ensure usability in the development of software applications overall. This way, the idea is not to provide a definitive and complete development framework, but a set of meaningful activities to help develop usable e-Government applications, thus providing methods to deal with stakeholder analysis and interests differentiation in a systematic way, and addressing the existing legislation that has to be considered when educing software requirements to carry out successful design solutions. This does not however mean that the rest of common development activities have to be avoided. In fact, the set of proposed activities have to be planned and estimated as part of the project planning, and even only a reduced set of the proposed activities and products might be used where applicable, depending on the project size. In general, our proposal is intended to ensure usability and thus increase end-user satisfaction in the long run. It is also an attempt to decrease design errors by considering the different stakeholders and fulfilling current legislation, also improving maintainability thanks to the detailed set of documentation and products produced during the development process.

As future work, we are working on refining the proposed activities through the experience. Also, we are working on defining corresponding pre and post development activities related to the set proposed. In addition, we are thinking of creating a comprehensive tool in order to help developers with the process execution, including new quality-based activities to improve process quality and facilitate audits.

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