A Reusable Requirements Catalog for Internationalized and Sustainable Blood Donation Apps

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Abstract: Blood donation mobile applications are efficient tools to increase awareness about the importance of blood donation acts and to attract blood donors. The aim of this paper is to define a reusable requirements repository (catalog) for blood donation applications based on the main related software engineering standards, e-health technology standards and literature. The catalog contains requirements regarding internationalization to bridge the cultural and language barriers among blood donors. It includes also requirements for sustainable blood donation applications which cover the individual, social, environmental, and technical dimensions of sustainability. This catalog can be very useful to develop, evaluate and audit blood donation applications and it can be adapted to other m-health applications.

1 INTRODUCTION

M-health technologies are transforming healthcare (Steinhubl et al., 2013) and empowering patients as they are assuming greater responsibility for their own healthcare decisions (Mirza et al., 2008; Norris et al., 2009). In fact, mobile applications (apps) dedicated to be used as personal health records (PHRs) allow patients to access and coordinate their lifelong health information through their mobile devices and to make appropriate data available to those who need it (Ouhbi et al., 2015e). Many apps have been used in a variety of health areas to improve patients' lives and their health (Idri et al., 2016; Ouhbi et al., 2015d; Zapata et al., 2015). Blood donation (BD) apps can play an important role to increase awareness among smartphone users about the importance of BD to ensure a sufficient blood supply in BD centers (WHO, 2011). BD act can save lives of patients in critical health situation (Tagny et al., 2010) and the ones who depend on a constant supply of blood (Williamson and Devine, 2013). More than one hundred and sixty free apps dedicated to BD are available in different app repositories (Ouhbi et al., 2015c).

Different types of BD apps exist (Ouhbi et al., 2015c): i) apps which help the user find donors, ii) apps which help the user find centers/hospitals at which she/he can donate blood, iii) apps which record the user's donation history, iv) apps which explain information about blood types to the user, v) apps which estimate the user's blood type by using the blood types of relatives, vi) apps which provide the user with information related to a BD center, vii) apps which calculate the date on which the user may donate blood based on the date of her/his last donation of blood, and viii) apps which provide the user with general information about the BD process. Therefore, there is a need for a requirement catalog which provides different stakeholders of BD apps with different requirements set to develop and/or audit BD apps.

BD apps should target as many smartphone users as possible to promote the act of BD and to recruit volunteers from different cultural backgrounds. In order to achieve this objective, the content of these apps should be designed in such a way that it can be adapted to various languages and regions without the need for engineering changes. The BD apps which fulfills internationalization (i18n) requirements can be valuable for users in multicultural environments (Zieliński and Ingram, 2004). Requirements of i18n should therefore be specified before developing BD apps in the early phases of development. Re-

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cently, research has begun to be undertaken into how to achieve sustainable software also known as green software (Erdelyi, 2013; Penzenstadler, 2014; Penzenstadler and Fleischmann, 2011). In fact, achieving sustainability of health and care systems is one of the objectives of research and innovation financed by the EU (h20, 2016). Sustainability is concerned with the economic, individual, social, environment and technical dimensions. To develop sustainable BD apps, requirements about sustainability should be considered.

This paper aims to develop a catalog for the inherent properties of BD apps. Software properties are either inherent properties or assigned properties (ISO, 2011b). The inherent properties determine the capabilities of a software product (ISO, 2007). They are permanent features and are opposed to assigned properties such as the software product price. They are part of software product requirements which can be classified as either functional requirements or software quality requirements. Functional requirements determine what the software product is able to do while quality requirements determine how well the software product performs (ISO, 2007). This catalog contains also i18n and sustainability-related information best practices for BD apps. The catalog presented in this paper, denominated ISBD-CAT, is based on the standards and recommendations from literature and will be implemented using requirements engineering techniques (Pohl, 2010).

The structure of this paper is as follows: Section 2 presents related work to this study. Section 3 presents the research methodology. Section 4 reports the requirements catalog of BD apps and presents an application example on the use of the catalog to evaluate BD apps. Section 5 discusses the finding of this study, presents implications for researchers and practitioners and outlines its limitations. The conclusions and future work are presented in Section 6.

2 RELATED WORK

Requirements engineering is a multidisciplinary activity of critical importance in software development (Nuseibeh and Easterbrook, 2000). Research in software development have found that the failures and deficiencies of software systems are often rooted in the requirements activities undertaken (Damian and Chisan, 2006; Smith, 2001). Requirements activities consist mainly of eliciting, analyzing, specifying and validating requirements (Bourque et al., 2014; reb, 2013). System requirements specification (SyRS) and software requirements specification (SRS) documents play a crucial role in software engineering (IEE, 2011). Requirements documents are essential to both communicate requirements to stakeholders in an understandable manner and define requirements in precise detail for developers (reb, 2013).

Many researchers have presented requirements catalogs for different disciplines. Toval et al. (Toval et al., 2002) have presented a reusable requirements catalog to improve information systems security. Based on this catalog, Martínez et al. (Martínez et al., 2010) have defined a personal data protection requirements catalog to audit personal data protection. A reusable standard-based requirements catalog for learning systems development has been defined by Toval et al. (Toval et al., 2011). Cos et al. (Cos et al., 2012) have presented an e-learning internationalization catalog for audit purposes. Filho and Barbosa (Filho and Barbosa, 2013) have proposed a requirements catalog for mobile learning environments. Jensen et al. (Jensen et al., 2009) have presented reusable security requirements for healthcare applications. As far as we know, there is no complete and well-defined set of requirements for BD apps. This paper is a step forward in this direction.

3 METHOD

3.1 Requirements Specification

Requirements for the ISBD-CAT have been identified from literature reviews on BD apps (Ouhbi et al., 2015a; Ouhbi et al., 2015c) and from previous research dealing with software quality (Ouhbi, 2015; Ouhbi et al., 2013; Ouhbi et al., 2015e), i18n (Cos et al., 2012; Fernández-Alemán et al., 2012) and sustainability (Calero and Piattini, 2015; Penzenstadler, 2014). Moreover, requirements from the following standards were also extracted:

- ISO/IEC 25010 standard (ISO, 2011b) for system and software product quality requirements and evaluation
- ISO 9241-151 standard (ISO, 2008b) for ergonomics of human-system interaction
- ISO/TR 18307 standard (ISO, 2001) for interoperability and compatibility in trusted health information interchange between software apps and systems in health care
- ISO/HL7 27931 standard (ISO, 2009) for data exchange in health care environments
- ISO 21090 standard (ISO, 2011a) for information interchange in health informatics
- ISO/TR 14292 standard (ISO, 2012) for the definition, scope and context of personal health

records
- ISO/TR 20514 standard (ISO, 2005) for the definition, scope and context of electronic health records (EHRs)
- ISO/TS 14265 standard (ISO, 2011c) for processing personal health information
- ISO 27799 standard (ISO, 2008a) for information security management in health
- The W3C standards (w3c, 2016) for web and mobile devices

Requirements based on Health Insurance Portability and Accountability Act of 1996 (HIPAA) recommendations (Carrión et al., 2011; Control et al., 2003) have been included in the catalog. Furthermore, usability guidelines from app repositories (Ouhbi et al., 2015b) have been taken into consideration in addition to requirements from software engineering for sustainability (SE4S) project (se4, 2016).

After identifying the standards and the other information sources, the corresponding parts of text relevant to functionalities, i18n and sustainability of BD apps have been identified, analyzed and specified. For requirements specification we have followed recommendations from the IEEE 29148 standard (IEE, 2011) which has replaced the IEEE 830 standard (IEE, 1998) and which is a guide to SRS. The quality of SRS documentation, which serves as an input to the design, coding and testing phases, is critical to the success of any software project (Ormandjieva et al., 2007).

3.2 Catalog Development

For the catalog development, guidelines from the IEEE 29148 standard (IEE, 2011) to develop the SRS and from SIREN (SImple REuse of software requiremeNts) (Toval et al., 2002) to develop reusable catalogs of requirements have been followed. SIREN, which is developed by the Software Engineering research Group (GIIS) at the University of Murcia, is a practical approach that can be used to create, select and specify the requirements of a software system on the basis of reuse and SE standards. Fig. 1 presents the generation process of ISBD-CAT. The catalog maintenance is an important task as it concerns the adaptation of requirements which are changed due to regulations, policies and standards changes or modifications in the BD apps.

4 RESULTS

Requirements concerning functional (shown in Table 1), i18n and sustainability (shown in Table 2) for BD apps are presented in this section. It should be noted that the requirements related to the economic dimension of BD app sustainability are not included in the ISBD-CAT because they are not inherent requirements.

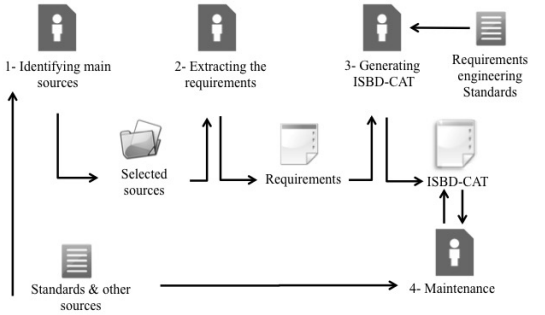

Figure 1: ISBD-CAT generation process.

4.1 The ISBD-CAT

The general structure of the requirements catalog, as recommended in IEEE 29148 standard (IEE, 2011), is shown in Table 3. In order to facilitate the search for and reuse of i18n and sustainability requirements, along with their integration into current instantiated requirements documents for BD app that is already under way, two new subsections dedicated for i18n requirements (i.e., Section 3.7.6) and for sustainability requirements (i.e., Section 3.7.7) were added as shown in Table 3. Each requirement identified has a predefined set of attributes that provide additional information on it, such as: unique identifier, source and priority. Traceability relationships are used to define relationships between the requirements identified which facilitates both reuse and maintenance tasks. As much as possible, we have followed the principles of minimal coupling and maximal cohesion in order to reduce the degree of interdependency (low coupling) and increase the existing conceptual and functional relationships (high cohesion) among requirements.

4.2 Application Example

This section shows how to apply the ISBD-CAT to evaluate a BD app. The Android version of the *Blood Donor+* app (https://goo.gl/LOeDNS), a free app, has been chosen to illustrate the evaluation process. The app *Blood Donor+* has been chosen because of its very high review score in *Google Play Store* (4.7 out of 5 stars). The first step of the evaluation consisted of carrying out a preliminary analysis of the app's work environment and its main features and functionality. The first author then carried out the evaluation

Table 1: Functional Requirements.

Functions
1) The app shall have an authentication procedure
1.1) The user should be able to choose in the app's settings whether to be authenticated or not
1.2) The user should be able to access the app using a login or social network account
2) The user should be able to manage his/her profile
2.1) The user should be able to edit data in the profile
2.2) The user should be able to remove data from the profile
2.3) The user should be able to add data to the profile
2.4) The user should be able to share data from the profile
2.5) The app shall create different profiles in the same device
3) The user should be able manage his/her BD record
3.1) The user should be able to edit the BD record data
3.2) The user should be able to remove data from the BD record
3.3) The user should be able to add data to the BD record
3.4) The user should be able to share data from the BD record
3.5) The user should be able to import data to the BD record
3.6) The user should be able to export data from the BD record
3.7) The user should be able to back up data from the BD record
4) The user should be able to find donors
4.1) The user should be able to find donors according to BD type
4.2) The user should be able to contact donors via email, SMS or phone
4.3) The user should be able to identify donors from his/her nearby location
5) The user should be able to find nearby BD centers
6) The user should be able to calculate his/her eligibility to donate blood
6.1) The app shall calculate eligibility from latest date of the user's act of BD
6.2) The app should notify the user if s/he cannot donate blood
7) If the app connects with EHRs, PHRs or third parties, it shall provide users with the possibility to interchange data
7.1) The user should be able to send data from the app to EHRs, PHRs or other parties
7.2) The user shall be able to receive data from EHRs, PHRs or other parties
8) The user should be able to consult recommendations for BD
9) The user should be able to consult BD types information
10) The user should be able to calculate his/her BD type
11) The user should be able to consult Help information to manipulate the app
12) The user should be able to have an offline access to the app
12.1) The user should be able to access the app without Internet connexion
12.2) The user should be able to edit data offline
12;3) The app shall save edited data offline

on the 14th of January 2017. Then, a Checklist to evaluate the app was generated from the ISBD-CAT. The Checklist was in the form of a questionnaire containing 27 questions so as to facilitate the work of the evaluator. We have discarded requirements from ISBD-CAT that are not applicable to this app. The questions can be answered by "Yes", "No" or "Partially". Table 4 presents the results of the evaluation.

The results of Q10 and Q19 were "Partially" as for Q10 donors can not add BD entries manually, they have to take a picture and link it to a BD event. While for Q19, the app displays only nearby location in Nepal. In the description of the app there was no mention that this app is dedicated to Nepal BD users. The coverage score of the *Blood Donor+* app is:
Total questions: 27. Yes (+1): 12. No (+0): 13. Partially (+0.5): 2.
$Coverage = 13 * 100/27 = 48.15\%$

To improve this app, a list of recommendation is provided below.

(i) An exhaustive description of the characteristics of this app including number of languages supported and geographical limitation should be available in Google Play. Potential users can therefore check if this app answers their needs.

(ii) The user should be given the option to manage his/her BD history and personal information manually.

(iii) The user should be able to choose other authentication options than login via Facebook.

(iv) The application should be available in more than one language to target as many donors as possible from different backgrounds.

(v) The app should be energy efficient by turning off on idle mode and allowing users to create different accounts in the same device. It should also allow users to have offline access to its content.

Table 2: i18n and sustainability requirements.

i18n
1) The tool shall be designed for cultural diversity and multilingual use
1.1) The app shall adapt its content to the user's language preferences
1.2) The app shall be available in different languages, the languages supported and the links for selecting them should be clearly presented
1.3) The app shall allow the user to switch between languages at more than one point while using it
1.4) The app shall allow the user to choose the language of the video or audio clips
1.5) The app shall adapt the online help section to the user's language preferences
1.6) The app shall adapt the human anatomy terminology to user's language preferences
1.7) The app shall show the text with a correct text align depending on the user's language preferences (e.g. Right align for Arabic language)
2) The app shall use pictures to explain ideas
3) The app shall use icons to explain its contents
4) The app shall use graphs to illustrate BD history
5) The app shall use appropriate formats, units of measurement or currency for international audience
5.1) The app shall adapt the number formatting to user's language preferences
5.2) The app shall adapt the currency to user's language preferences
5.3) The app shall adapt the units of measurements to user's language preferences
5.4) The app shall adapt the temperature to user's language preferences
5.5) The app shall adapt date and time types formatting to user's language preferences
5.6) The app shall adapt the phone numbers to user's language preferences
5.7) The app shall adapt the address to user's language preferences
6) The app shall take into account the start day of the week by geographic location
7) The app shall control the advertisements showed to the user to avoid cultural discrepancies
8) The app shall allow the user to manage personal information, such as different countries' specific legislation or regulations regarding user ownership of personal information
8.1) The user should be able to adjust personal information in accordance with different countries' specific legislation or regulations regarding user ownership of personal information
8.2) The user should be able control personal information in accordance with different countries' specific legislation or regulations regarding user ownership of personal information
8.3) The user should be able to process personal information in accordance with different countries' specific legislation or regulations regarding user ownership of personal information
Sustainability
1) The app shall have a positive individual impact
1.1) The app shall respect security and privacy of the user
1.2) The app shall promote personal health and well-being of the user
2) The app shall have a positive social impact
2.1) The app shall promote interaction among users
2.1.1) The app shall connect to social networks
2.2) The app shall promote social solidarity among users
2.3) The app shall improve social services for users
3) The app shall have a positive environmental impact
3.1) The app shall reduce transportation means to find/donate blood
3.2) The app shall be convenient for frequent use
3.3) The app shall connect to other IT resources
3.3.1) The app shall back up data in data repositories, drivers or cloud systems
3.3.2) The app shall use device features such as bluetooth and/or near field communication (NFC) technologies
3.3.3) The app shall connect with maps repositories to display locations
3.4) The app shall be energy-efficient
4) The app shall have a positive technical impact
4.1) The app shall easily adapt with future changes
4.2) The app shall shut down in idle mode

5 DISCUSSION

In spite of the undeniable relevance of i18n and sustainable software in our IT-driven globalized world, no specific standards dealing with software sustainability and e-health i18n were found. The catalog presented in this paper is therefore very beneficial for different BD app stakeholders. In fact, developers can use all or some requirements of this catalog to develop internationalized and sustainable BD apps.

Table 4: Questionnaire to assess the *Blood Donor+* app.

ID	Question	Result
Q1	Is the user able to access the app using a login or social network account?	Yes
Q2	Is the user able to choose in the app's settings whether to be authenticated or not?	No
Q3	Is the user able to edit personal data in the profile?	Yes
Q4	Is the user able to remove personal data from the profile?	No
Q5	Is the user able to add personal data to the profile?	No
Q6	Is the user able to share personal data from the profile?	No
Q7	Is the user able to consult blood donation recommendations?	Yes
Q8	Is the user able to edit the blood donation record?	Yes
Q9	Is the user able to remove data from the blood donation record?	Yes
Q10	Is the user able to add data to the blood donation record?	Partially
Q11	Is the user able to share data from the blood donation record?	Yes
Q12	Is the user able to import data to the blood donation record?	No
Q13	Is the user able to export data to the blood donation record?	No
Q14	Is the user able to back up data from the blood donation record?	No
Q15	Does the app promote interaction among users via social networks?	Yes
Q16	Does the app promote social solidarity among users via a rewards system?	Yes
Q17	Does the app adapt its content to the user's language preferences?	No
Q18	Does the app present in its description the number of languages supported?	No
Q19	Is the user able to find nearby healthcare centers?	Partially
Q20	Does the app use pictures to explain ideas?	Yes
Q21	Does the app use icons to explain its contents?	Yes
Q22	Does the app use graphs to illustrate health data history?	No
Q23	Does the app connect to social networks?	Yes
Q24	Does the app connect with maps repositories to display locations?	Yes
Q25	Does the app shut down in idle mode?	No
Q26	Does the app support different profiles in the same device?	No
Q27	Is the user able to access the app without Internet connexion?	No

Table 3: Table of contents (IEE, 2011).

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4. Verification
5. Appendices
5.1 Assumptions and dependencies
5.2 Acronyms and abbreviations

BD health organization or development companies which are willing to promote BD via apps can elicit and specify their requirements from the ISBD-CAT. Moreover, the i18n and sustainable requirements are adaptable and can be reused for other e-health app such as apps for cardiology or oncology.

Furthermore, audit organizations or BD app stakeholders can use the ISBD-CAT to evaluate and/or audit BD apps. A checklist can be generated from the ISBD-CAT. To that end, a reuse-based approach to generate new requirements documents from the ISBD-CAT should be applied. This step is necessary, since the variation points of the reusable requirements, which are basically parameterized requirements and traceability relationships, must be resolved in reuse time in accordance with the system evaluation and/or audit. The requirements documents will then be mapped onto items of the Checklist in order to carry out the evaluation and/or the audit of BD apps.

The catalog can be applied in different scenarios and adapted to fully capture the needs and constraints of BD app development. The requirements catalog contents will be subject to continuous improvement through the incorporation of new knowledge originating from additional information sources, such as other recommendations, standards or policies.

This study may have several limitations, such as: (i) the application example using only one app may not be sufficient to demonstrate the applicability of the catalog. However, the application example was presented to give insights on how to use the ISBD-

CAT in the evaluation of BD applications; and (ii) the catalog does not contain requirements for the economic dimension of sustainability. They should be identified to complete the sustainability aspect of the reusable catalog.

6 CONCLUSION AND FUTURE WORK

This paper has presented the ISBD-CAT, which is a reusable requirements repository for BD stakeholders to assist them in eliciting, specifying and validating requirements for internationalized and sustainable BD apps. The requirements presented in this study have been primarily established from the results of literature reviews conducted in this domain and analysis of standards related to software engineering and e-health. For future work, we intend to make progress in the improvement of the requirements catalog by harmonizing the multiple requirements that are scattered throughout different sources. Moreover, we intend to develop an audit method denominated ISBD-AUDIT to determine whether BD apps meet requirements cited in ISBD-CAT. Furthermore, an evaluation of ISBD-AUDIT will be conducted in a BD center in Murcia (Spain).

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