A Repository of Software Requirement Patterns for Online Examination System

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Abstract

Over the past decade or so, the web has been embraced by millions of people as an inexpensive channel to communicate and exchange information amongst them. Consequently, web application development has emerged as a prominent aspect of information systems development. All web applications have certain features in common, therefore, a set of requirements are being used repetitively for the web application development. This repetitive occurrence of requirements patterns can be reused. This paper puts forward a standard Software Requirement Pattern template and a repository of the various types of Software Requirements Patterns for an online examination system which can be used repetitively by the requirements engineer for a faster requirements elicitation, analysis and validation. This results in a more complete, consistent and a high quality of the requirements book.

Keywords: *Requirements, Pattern, Template, Repository*

1. Introduction

Web applications are fast emerging as a popular area of information systems development [1], [2]. The availability of the internet as an inexpensive channel of communication and information exchange has resulted in its increased rechability. This has lead to a growing demand to develop web based applications in almost all the spheres of life. Web applications refer to applications accessed via Web browser over a network and developed using browser-supported languages (e.g., HTML, JavaScript). For execution, Web applications depend on Web browsers and include many familiar applications such as online retail sales, online auctions, online education, online examination and webmail.

The software requirements gathered for web applications representing completely different aspects have been found to have a set of common requirements. Resultantly, it has been observed that a pattern emerges in the software requirements gathered for these applications which can be reused. Reuse is a vital activity of a Software Development Process [3] that is both essential and beneficial to the development of the software [4]. The reuse of software requirements is helpful to a requirements engineer in elicitation, analysis, validation and documentation of software requirements. It ensures faster acquisition of software requirement specifications, of better quality and more dependable both in contents and syntax [5].

A pattern, in general, describes a problem which occurs repeatedly. It in a way reuses the abstract knowledge about the problem and then describes the core of the solution to that problem. A pattern therefore, is a description of the problem and then reveals the essence of its solution - which can be reused infinitely [4].

Software engineers have adopted the notion of pattern in several contexts, especially in relation with software design (e.g., software design and architectural patterns), as well as in other development phases. We are interested in the use of patterns for the requirements engineering phase, namely Software Requirement Patterns (SRP).

Software Requirement Patterns are a type of artifact that may be used during requirements elicitation that also impact positively in other activities like analysis, documentation and validation. The different phases of Requirements Engineering [6], in which the SRP can be used are shown in the figure below.

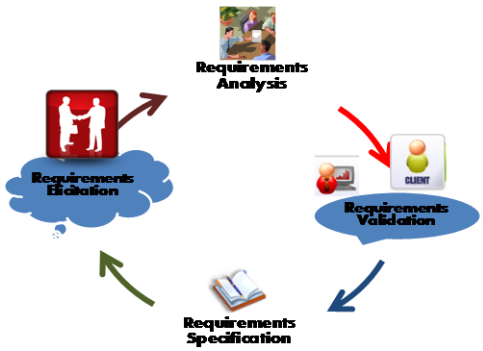

Fig 1. Requirements Engineering Model

The literature survey conducted so far has found some approaches for SRP only. Recent approaches using SRP templates for writing software requirement specifications can be found in the work of Withall [7] and in the Pattern-based Requirements Elicitation(PABRE) by Renault et al [8],[9] and Konrad [10]. Use case template works of Rumbaugh [11] and Cockburn [12] are also there. Other similar works are the *Volere Requirements Specification Template* [13], that defines many types of non–functional requirements, and the *User Requirements Document Template* for the European Space Agency (ESA) PSS–05 standard developed at CERN [14].

As stated earlier the number of pattern occurrence increases for a specific area and is easier to navigate and implement as compared to a vast generic system which requires complete understanding of the existing catalogue of SRPs. In addition it has been observed that the area of Web application systems development leads to a higher frequency of certain requirements in comparison to a general information systems development. In this paper we have focused in a particular area of Web Application namely, the Online Examination System (OES). We have exhaustively studied the requirements for Online Examination Systems to generate a standard SRP template and a comprehensive SRP Repository suited to the specific area of OES.

The advantages of using SRPs for OES requirements are, that it decreases the time spent to perform the elicitation of the requirements for an OES. The SRP repository for an OES is more to the point, easy to navigate and also guides the requirement engineer to detect inconsistencies and identify missing requirements during requirements elicitation and analysis. As a result we have a more complete, consistent and a high quality of the requirements book [8].

In this paper there are five sections in the first section we try to explain the notion of SRP, related work and advantages of requirement patterns in context of the OES. In the next section, we define a standard software requirements template for OES. Further, in section 3 we present a repository of requirement patterns as identified in this research work for the OES and their pros and cons. Later, in section 4 we have tried to illustrate the use of the repository with the help of an example. In the end in section 5 we conclude stating the possibility of extending this work further.

2. Requirements Pattern Template for Online Examination System

In order to define a standard SRP template and a repository for an OES the procedure adopted for our research work, as shown in Figure 2 has evolved through the following phases:-

1. Consolidation of the requirement for online examination systems from almost ten to fifteen on line examination portals.

2. Definition of pattern structure: Different parts of a pattern were identified and their relationships were established. Fundamental properties of requirements were also taken into consideration in the search of criteria for designing the structure of the pattern. Requirements information to be expressed in the template was accordingly divided into subparts.

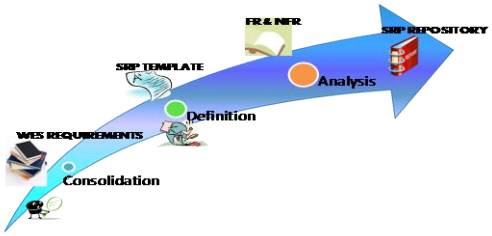

Fig 2 Research Steps

3. Analysis of the functional and non-functional requirements to generate a repository of SRPs for OES. We started with the basic patterns of Withall [7], Hoffman[15] etc. and progressed towards an enhanced, more structured and suitable repository for OES by combining some existing patterns and eliminating the superfluous ones, as well as creating some completely new patterns.

Requirements gathered for the development of an information system are of two types, namely functional and non-functional. The functional requirements are defined as requirements referring to the functionalities and behaviour of the system; they are quantifiable **[**16**]**. The term "non- requirements, which focus on "what" the software does." [17] as such they are qualitative in nature.

We are interested in expressing both functional and non functional requirements with the help of a standard SRP template for OES. Therefore, an exhaustive analysis of the requirements for a sizeable number of online examination systems was done. The analysis reveals a large number of common objectives and targets in case of an OES such as:- Registration of students for an exam, maintaining the data of an enrolled examinee and examiner, ease of website navigation, user friendliness, simplicity of data content representation, conducting Online Examinations Display of results, Increasing enrollment, Increasing profit, Minimizing costs and expanding the reach etc.

In order to define the structure of a SRP template for the above stated recurring requirements in an OES, the fundamental properties of the requirements were examined. Thereafter, both explicit and implicit facts were scrutinised and incorporated to identify the structure of a requirement pattern template. A requirement pattern is a template and guide to writing a particular type of requirement such as inquiry, information storage etc.

In this section we define a template somewhat similar to the templates of those used by Withall [7], Renault et al. [8], Volere [10], Duran et al[18], Gamma *et al.* [19].The Software Requirements Pattern template defined by us is enhanced, more structured and tailored for use in the area of OES development than those stated above. It is designed to incorporate the recurring facts in case of an OES which are not observable in templates for generic use. The SRP

template stated in detail in Table 1 is structured to describe the following: goal or purpose which it aims to achieve. The content attached with the specification details would have a fixed part and a variable or an optional part to describe the same. In the case of functional requirements this may also involve pre and post conditions to be fulfilled to carry out the sequence of steps to achieve this goal.

In the case of Non-functional requirements this could be a simple specification data. There might be constraints attached to a requirement and the importance and urgency of fulfilling that requirement too. All these subparts are used to define the structure of a SRP template given below.

The notation used to describe the standard SRP template is the following: words between <…>represents the fixed part and must be properly replaced, words between { … } and separated by commas represents variable and options respectively; only one option must be chosen. The meaning of the template fields is as follows:-

Pattern Identifier and descriptive name: every requirement must be uniquely identified by a number for example U01, D02 and a descriptive name this field is used to give a unique name e.g. Presentation, Navigation to the Requirements Pattern.

Pattern Description: this field should be completed with the information about the relevant concept for storage for e.g. to display the content for online registration in the form of html, javascript forms or presentation files.

Table 1: Software Requirements Pattern Template

	Software Requirements Pattern Template
Pattern Name	<descriptive name>
Pattern Id	<unique identification number>
Pattern Description	The system shall store the information corresponding to <relevant concept>
Author	<author name>
Source	< Source of requirement >
Classification	{Functional/ NonFunctional Requirement}
Classification-Purpose facets	<Type of Functional or Non functional requirement>
Goal	<Gives the purpose of the requirement pattern>
Applicability	< Description of area in which the pattern may be applied.>
Constraints	<Relevant Constraints if any>
Content data-Specific	<Specific data about the relevant concept> ….
Content data-Optional	{optional data about the relevant concept} { ....}
Pre , Post and Execution conditions in FR	{Only for Functional Requirements}
Sequence /steps of action	{Only for Functional Requirements}
Extra Requirement	<additional associated requirements to satisfy this one properly>
Related Requirement Pattern	< Relevant related requirement pattern name>
Importance	<importance of requirement>
Urgency	<urgency of requirement>
Frequency	< No. of times it is applied>
Examples	< Relevant Examples of the above stated pattern>

Author: this field must contain the name and organization of the author, i.e. the requirements engineer. For e.g. Sangeeta Srivastava, BCAS.

Source: this field must hold the source of generation of the given requirement whether it is the designer, developer or customer etc. For e.g. ABC Software Consultants ltd.

Classification and Purpose facets: This field states whether it is a functional or a non-functional requirement and the purpose facet of FR or NFR to which it belongs as in [20].

Goal: this field must state the business goals this requirement strives to achieve. For e.g. To display data content on the website.

Applicability: this field states the area of application of this SRP template in order to guide the requirements engineer in its selection and usage later on e.g. Report display.

Constraints- this field must contain the constraints if any related to the application of the requirement. An inquiry must be responded to within 5 seconds.

Content Data Specific or Optional data: this field must hold a list of specific or optional data associated with the relevant concept .For e.g. Data Content to be displayed must be presented as a list, for e.g. list of exams and their subject courses for which a student can register for appearance later.

Pre/ Post and Execution Conditions and Sequence of Steps- Conditions to be satisfied before after and during the execution of the sequence of steps respectively in the

use case. This is only in case of Functional requirements. This does not hold for non functional requirement.

Extra Requirement- this field states any requirements over and above these which are required for the satisfactory completion of this requirement .e.g. the online application should run on all browsers.

Related Requirement Pattern- this field lists Requirement Pattern in the repository for OES which are related to the given pattern. For e.g. User Registration pattern is also related to User Authorization pattern.

Frequency- this field mentions the frequency of application (i.e. 1-n) of this requirement pattern**.**

Importance, Urgency: these fields indicate how important and urgent the requirement is for customers and users. They can be assigned a numeric value or some enumerated expressions such as *vital*, *important* or *would be nice* for importance, or such as *immediately*, *under pressure* or *can wait* for urgency, as proposed in [21].

The explanation given above is illustrated with the help of an example of Examinee/ Student Registration Pattern given below in Table 2.

Table 2: Example of Examinee Registration Pattern Template

EXAMINEE REGISTRATION	PATTERN
Pattern Name	Examinee Registration
Pattern Id	U01
Author	SangeetaSrivastava
Source	Requirements Book for ABC Online Examination Portal
Classification	Functional
Classification-Purpose facets	Usability, Readability
Goal	To register an examinee who wishes to appear for a given exam at a specified centre, and schedule.
Applicability	For Student/Examinee Registration
Constraints	None
Content data-Specific	• User Name, • Sex, • Address, • DOB. • Telephone , • Email • Centre of Exam • Date of Exam • Time of Exam • Name of Exam • Exam subject
Content data-Optional	• Mobile No. • Alternate Email address
Pre/ Post and Execution Conditions	**Pre Condition** – Check availability of centre, date and time for the selected examination schedule. **Post Condition-** Create Student Id, Login and store student information, and exam registration information. Roll No. and admit card to be generated after successful fee transfer **Execution Condition** - Do not register a student registered earlier. Do not Enroll student if the centre, date, time of exam availability is not confirmed. Block the examination schedule only after confirmation from the student and fee payment
Sequence of steps	1. Student presses the sign in button 2. Registration Form opens and student fills in the information 3. Student selects time, date and centre for an exam

	4. Check availability of centre, date and time of exam and report 5. Student confirms his selection of time, date and centre of exam and submits the form 6. Registration details consistency and completion checked 7. Check letters and password verified 8. Fee transfer form opens and student fills the information. 9. On successful transfer of fees display message or report 10. Submission of registration form permitted for enrollment for exam. 11. Generate exam roll no. and admit card
Extra Requirement	Should work with all web browsers, OS and data to be stored in a dbms
Related Req Pattern	User Authentication RP
Pattern Description	The system shall store student registration and examination registration details and generate student roll no , login with password and admit card
Importance/Priority	Vital
Urgency	Immediately
Frequency	High
Examples	Student Registration, Faculty Registration

3. Repository of Requirement Patterns for OES

A list of requirements for defining a SRP repository has been constructed from an exhaustive analysis of requirements for online examination portals. The repository aims to aid collaboration between the various stakeholders involved in the development process by using a common repository which can be used as a guidance tool both by the requirements engineer, software designers and developers.

In order to assemble an exhaustive SRP repository we need to capture both functional and non-functional requirements, as these types of requirements are less sensitive to changes in the problem domain. SRP shows a great percentage of reuse for both functional and non-functional requirements needed in Online Examination System Requirement (OESR) specifications.

The Table 3 below gives the current requirements patterns in the repository and their respective intentions. It acts as a checklist for Requirement Engineers who are gathering requirements for an online examination system and guides them towards the generation of a high quality requirements book by preventing the use of missing and inconsistent or incomplete requirements

.

Table 3: SRP Repository for OES

Requirement pattern name	Description
User Operation	to specify the ease of user interaction and user operation on and across the website and examination paper E.g. buttons and tabs on the website and question paper.
User registration	to specify how new users are registered and their information is stored for authentication later.
User authentication	to specify that a person must log in and make their identity known to the system before they can start the registration process on the system.
User authorization	to specify that a set of users is authorized or not to access or see certain activities .
System Operation	To specify the platform to be used to build or run the system or with which the system must be capable of interacting or compatible. E.g. Web Browsers, OS, Javascript, HTML and DBMS

Information Storage	to specify how a piece of information or content is to be represented and stored. E.g. storage of information in a DBMS or in a particular file format like PDF, Excel, Javascript etc .
Presentaion	to define a visual elements and interface layout of the OES registration and examination website
Information Content Representation	to define a scheme for representing information content as text, image, audio and video .E.g. presentation and text for examination paper
Formula Calculation	To define the formula to be used for calculation of a given data field. E.g. date of birth ,result summation.
Navigation	to specify how to navigate in the website or the question paper.
Data lifespan	to specify for how long a certain type of information must be retained in the active system after which it can be deleted or stored in history records.E.g Results
Data History	to specify which data is to be moved at what time from the active storage system to the history records.E.g. Previous years results and examinee data.
Entity Definition	to define an entity for which information is to be stored and its lifespan.E.g. student
Inquiry	to define a screen display function that shows specified information to the user. E.g. Exam centre availability inquiry
Report	to define a report that shows specified information to the user.E.g. Exam centre availability report
Response time	to specify how much time the system may take to respond to a request.

Throughput, Effeciency	to specify a rate at which the system—or a particular inter-system interface—must be able to perform some type of input or output processing.
Dynamic capacity	to specify the quantity of a particular type of entity for which the system must be able to perform processing at the same time .E.g. no of logged users at the same time
Static capacity	to specify the quantity of a particular type of entity that the system must be able to store permanently (typically in a database).Total no. of user database
Error notification	To display in case of an error as specified or required
Availability	to define when the system is available to users: the system's "normal opening times" (which could be "open all hours") plus how dependably the system (or a part of the system) is available when it should be.
Expandability	to specify a way in which a system must be able to expand later to accommodate growth in volume.
Installability	to specify how easy it must be to install or upgrade the system.
Approval	to specify that a particular action must be approved by another authorized person before it can take place.E,g. Examinee Verification by invigilator
Fee	to specify any fee the system must calculate, report or levy.
Transaction	to define a type of event in the life of a living entity, and/or a function for entering such a transaction. E.g. Fee transaction
Interface interaction	To define the type of external interface will

	interact with the system like the credit card payment companies.
Customizability	Adaptation as per user custom needs.
Concurrence with requirements	Conformance to the requirements documents which might be external to the system but required
Security	Against threats ,corruption and hacking

There are thirty requirement patterns in all some of the patterns are applicable to the majority of online examination systems, while other patterns are more specific to individual systems. More detailed information is provided in the respective complete pattern description.

Pros and Cons

For requirements engineering experts, a benefit from using this method is a database of requirements elicitation experiences that might be used for statistical analysis. Faster requirements elicitation process. The reduction of time comes from the fact that patterns offer "ready to use" requirements and that the repository covers the most common functional and non functional requirements.

The repository aims at achieving a higher quality of the requirements book. By ensuring the completeness of the requirements generated for an OES. If we provide a complete patterns repository, we may contribute to obtain complete requirement books.

However, we think that we may never have a strictly complete patterns repository since there may always exists the need of requirements that are very specific of projects, and it would not have sense have them as patterns.

The idea is that the patterns repository will be unambiguous. Taking into account the pre processing, the requirements extracted from patterns will very rarely have any ambiguity and will be consistent. Further, the backward traceability of requirements in the requirement book, which were extracted from the patterns repository, is partially guaranteed by the repository as we maintain the sources from where the patterns were derived.

4. Example of ABC Online Examination System

For exhibiting the benefits of the SRP repository for OES we illustrate the process of using the repository with the help of an example below. The primary goal of ABC OES is to provide an online examination portal.

The main goal of the organization is to provide i) student registration and ii) examination platform with the following objectives in mind: Provide a 24*7 platform independent registration and online examination portal working on all browsers. . It should be a very simple and user friendly website.

An online examination system should allow a prospective student to log in, select the examination for which he wishes to appear, further choose the subject option for that examination and set the centre date and time of the examination based on the availability.

Once all the selections have been made successful transaction of the examination fee should be made, which on completion should store the examinee details, block the centre, date and time slot selected and generate an admit card showing all the details of selection and his examination roll number.

On the day of the examination the student should present his roll no at the examination centre which the OES should authenticate and if successful then the examination paper containing the questions should be presented to the examinee at the scheduled time and the stop clock should start.

The examinee would have the option to choose an answer out of the multiple choices given to him and submit when he is ready within the exam time limit. The examinee should also be able to move from one question to any other question as he wishes. Ten minutes before the expiry of the exam time limit a message to be displayed to submit the question paper.

On the expiry of the time limit the exam paper to be closed, marks to be calculated based on the answer sheet in the system and the result should be displayed. An enrolled student remains in the active system till he appears for the exam and henceforth would be able to see his result after login up to six months, after six months his details would be stored in archive.

The target audience of the website will be students that may have diverse backgrounds, so it would be beneficial to give an online demo on usage of the website and mock question paper drill.

In a day there maybe 1,00,000 users with at least 10,000 users at the same time. The results and the admit card should also have the option of being sent by using email.

Overall security of the system should be high and accessibility to the students for an exam should be limited to the question paper presented to them at the time of exam.

An examiner would be allowed to create a login and after verification only will be allowed to upload question papers and its answer sheet into the question bank. However he

/she would not have access to the question bank from which the questions will be chosen randomly to be presented to an examinee at the time of examination. In order to gather the requirements for the OES from the statements given above in a comprehensive manner we will visit the repository in Section 4 and carry out the following process:-

The process consists of four steps namely gather, check, select or identify, extract and apply SRP by
filling in the relevant specific data.

1. The requirements engineer gathers the requirement for the online examination portal to be developed by him for ABC OES.

2. He checks the repository of Requirement patterns available for a OES and based on the description given he identifies the required patterns and extracts them from the repository

3. Further, he fills in the requisite details for completing the requirements pattern for requirements elicitation and analysis.

4. This process would yield related requirement patterns, constraints and extra requirements for the chosen SRP and guides the requirements engineer in the requirements identification and elicitation process.

5. The requirements engineer then repeats steps 2 to 4 till all the requirements have been fulfilled .

Keeping the above goals in mind a requirements engineer can start with the repository of requirement patterns given earlier in Section 3 and the patterns listed below in Table 4 can be used for the satisfaction of above stated goals partially. However, Repeating steps 2 to 4 would yield a more comprehensive and complete set of patterns from the repository given in the section above.

Table 4: XYZ OES Requirement Patterns

GOAL	Requirement Pattern Selected
Simple and User Friendly website	User Operation
User Login	User Registration, User Authentication and User Authorisation, Entity Definition, Inquiry, Report
Online Examination	Information Storage
24*7 Availability	Availability
Platform Independant	System Operation
Safety of the system	Security
Fee Statement	Fee
Video and Text Presentation	Presentation
Search course by topic, subject etc	Navigation, Inquiry, Report, Response
	Time and Efficiency
Question Paper Storage	Information Storage
Question paper Presentation and Navigation between the paper	Navigation, Presentation
Question Paper generation	System Operation
Result display	Inquiry, Report
Result Calculation formulae	Formula Calculation

5. Conclusion and Future Work

The contribution of my work would be the definition of SRP template and repository for OES that may be used during requirements elicitation that would also impact positively in other activities like documentation and validation. Better requirements result from use of patterns because requirement patterns help point out issues that merit closer scrutiny and coincidentally preclude the analyst from overlooking vital points. Patterns boost analyst productivity by providing a great starting point and guidance, the analyst begins with a substantially already-written requirement, rather than having to start from scratch.

These templates and patterns have been successfully applied in some academic practices. It has been used productively in the area of Web based Education System earlier. In future we plan to extend it to a broader area of Web application development. Some possible lines for future work may also include adapting templates to generate use case maps and further discovering more patterns, especially for non–functional requirements, creating a requirements repository for promoting reuse to expand the reach of this repository to other web applications.

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