CONSTRUCTING PATTERNS VERIFICATION CRITERIA BASED ON QUALITY ATTRIBUTES WEB SECURITY CONTEXT PATTERNS CASE STUDY

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Abstract

The proposed designs for a particular space were broadly utilized for the idea of reusing of the determined issues to comparable ones. The confirmation criteria for proposed designs assessment are one of the critical variables that influence the examples quality. This exploration proposed designs confirmation technique and criteria taking into account quality credits keeping in mind the end goal to enhance designs legitimacy. The strategy was made out of 4 stages, check criteria foundation, trial outline, test execution and results examination and report. The two extra confirmation criteria, Knowledge Transformation and Patterns Application were proposed while three criteria, Goal, Source and Representation were proposed by Breaux (2012). Likewise, the quality characteristics of 5 check criteria were presented and connected for a situation study. They were Achievement, Functionality, Understandability, Completeness and Consistency, and Clarification and Application. From our past work, the develop examples of Web Security Context Patterns (WSCP) were utilized as a contextual analysis. Specialists in both the scholarly world and industry segments were chosen to assess the WSCP designs utilizing the 5 assessment criteria in view of the proposed quality characteristics list of issues. By using these verification criteria, the experimental results indicated that the quality of WSCP patterns was assessed in a high level of satisfaction with an overall mean above 4 from a 5 scale.

Keywords: Quality Attributes; Verification Criteria; Goals; Sources; Representations; Transformations; Applications; Web Security Context Patterns;

1. Introduction

Software patterns, one of the feasible solutions based on reuse approach, is widely adopt in software engineering field since the main purpose of the patterns is to applied the proven solutions for a specific problem in a given domain to a
similar problem [1]. Besides, software patterns have been constructed and applied to various software engineering processes. For instance, requirements patterns have been proposed for preliminary gathering a potential list of needs in software requirements process [2]. Moreover, Object-Oriented design patterns have been introduced for developers to select the appropriate software architecture to support design goal qualities in term of overall system performance and maintenance point of view [3]. In a similar way, security is one of the important concerns of system quality requirements for different types of applications such as e-commerce, critical system and information management system [4]. Security patterns have been established to cover the main properties of core security services, Confidentiality (C), Integrity (I), Accountability (A), and Availability (A) for any project to apply for a specific security need [5]. In term of application effectiveness, the empirical study was reported that the designer treatment group prefers to work with the support of security patterns [6]. However, the use of proposed security patterns for a specific system characteristic may be needed to modify or improve to cover the system features. For example, another work was studied to identify the feasible gaps of security patterns for a distributed system [7]. There were many researches [8-11] have been proposed new types of security patterns for a specific domain. Likewise, our prior work, the Web Security Context Patterns (WSCP) have been constructed in order to improve security concerns in the context of web user agents [12]. It should be ascertained that the proposed patterns comply with the target problems. Thus, assuring the proposed patterns quality, patterns verification process help in improving two major quality attributes, correctness and completeness. Thus, it is necessary to verify the WSCP with the appropriate evaluation method to assure the conformity and quality concerns.

Previous researches have shown that the identified quality attributes were used properly with the aims of patterns evaluation [13-15]. In addition, the empirical study has been established and introduced three concepts for patterns validation. There are Goals (What is the goal of the patterns), Sources (What is the sources of knowledge), and Representations (How is the pattern described?) [16]. Our research focus is to consider whether there are additional verification criteria help to improving patterns quality. There are two challenging of patterns construction:

1) **Knowledge Transformation** from sources to representation and

2) **Application of Patterns** reflecting the context of use. For the first challenge, the construction of the patterns content representation created from the source knowledge is required knowledge transformation. Thus, some missing part or
incorrectness of content may be occurred. For the second one, verification between the context of use and the proposed example resolved part should be performed. Even though, there was a research [17] informed that the application of patterns can be effectively done during the software analysis and design phase. We believe that this verification part can be performed by expert from investigating the example resolved part whether the solution application is reasonable. Thus, knowledge transformation and patterns application are proposed as two additional patterns verification criteria. The guideline for patterns construction and inscription for capturing necessary context information was reported in [18]. This work provided us the important evidences for patterns verification in both knowledge transformation and patterns application. The remainder of this paper is organized as follows: section II describes the proposed pattern and the five verification criteria. Section III addresses quality attributes and a list of questionnaires. Section IV describes a plan for the experiment. Section V executes the experiment. Section VI discusses the experimental results. Section VII summarizes the findings and states future work.

2. Related Work

A. Web Security Context Patterns

The knowledge of patterns was first studied in term of design patterns that capture together a cyclical architectural procedure and an instruction for applying this knowledge [3]. In this regard, security patterns was built on the success of design patterns. Security patterns covered all CIAA security

![Fig. 1. Web Security Context Patterns’s Relationship [12]](image)

**Instance of Web Security Context Pattern[12]**

**Description**

This pattern describes a basic to handle the occurrence errors then signal them to users by a severity level ranges from low to high risk. These level are an error signaling, warning message, and finally danger message.

**Context**

Applying this pattern in order to handle an error occurs in web interactions. A situation similarly to one of errors that stated in WSCP-54

**Error Signaling** handles with the generic errors that might not harm to the system. Error signaling SHOULD be phrased in terms of threat to user's interests, not technical occurrence.
**Warning Messages** are intended for situations when the system has good reason to believe that the user may be at risk based on the current security context information, but a determination cannot positively be made. Warning message MUST interrupt the user's current task, such that the user has to acknowledge the message.

**Danger Messages** are intended for situations when there is a positively identified danger to the user. These interactions MUST be presented in a way that makes it impossible for the user to go to or interact with the destination web site that caused the danger situation to occur.

**Example resolved**

According to WSC-UseCase 22: Frank clicks on the link and is directed to a phishing site. The phishing site has been shut down as a known fraudulent site. In this case, Error signaling should be phrased in terms of threat to user's interests, not a technical occurrence. Therefore, when Frank clicks on the link instead of the generic Error 404: File Not Found page, he receives error message states that the page has been shut down due to fraudulent site. Frank is now notices that what’s going on.

**Consequences**

Handling and signaling the errors by the severity levels are influence to the user experience with the effective warning.

Overview of Patterns Validation services that capture principles and best practices were introduced [5]. In exchange for a multiplicity of contexts, a large number of security patterns have been proposed for a specific domain [8-11]. Constructing early security patterns from regulatory documents ensures the consideration of regulatory requirements in the essence and document during the software development [7]. From this perspective, the Web Security Context Patterns (WSCP) [12] has been constructed through textual and structural analysis of the Web Security Context: User Interface Guidelines (WSC-UI) [19].

As a result, 18 patterns have been proposed as shown in Fig. 1 are represented by class diagram with the entity of patterns and their relationship. Furthermore, Table I was detailed for the Error handling and signaling pattern as the example of Web Security Context Pattern. In this regard, WSCP the proposed patterns has become a treatment in an experimental design in order to archive the purpose of pattern verification. In this way, The WSCP have been being verified and the evidences are going to be supported in the verification criteria investigation.

B. Verification Criteria
The study of verification criteria has become an important aspect of patterns verification in order to affirm a good quality of the implemented patterns. Regarding to Hammar (2010), the reviewed papers are lacking in empirical validation. A characteristic of the empirical group have been categorized by the discussions on context, study design and validation description quality [20]. In this mean, the experimental treatments in study design are evidently defined as with the context of pattern goals. By the way, the validity description quality need to be analyzed. Thus, numerous quality criteria [14] have been studied in order to evaluate the patterns. Moreover, a common finding in the validity of patterns are from the goals of pattern, the sources of knowledge that the pattern is derived, and the representation is described the pattern [16]. Despite the patterns validity was identified, the attention for patterns verification are need to be more explore. Therefore, the account of pattern characteristics are exposed validity in patterns. In other words, the patterns developments process overcome an attribute that signifies the quality of an implemented patterns. As revealed by the evolution of pattern [18]. In considered of transformation, while writing a pattern, a draft documents such as a traceability matrix has detailed about the origin of knowledge was matched to the pattern outcomes. In the furtherance of verification also provide the applicability of patterns for analysis and design of secure software in an environments [17]. So that the application was attested by the context, solutions, example and example resolved that proposed in each part of patterns. In the interest of the five verification criteria, GSRTA: goals, sources, representation, transformations, and application are further investigated for the measuring quality attributes on the next chapter.

3. Identify Verification Criteria

In this section, the quality attributes were explored for each verification criteria remarked in section II. Further, the evidences from the proposed patterns were revealed to support the concept of quality attributes. As a result the verification issues were declared in order to measure the validity of the patterns. The process of identifying verification criteria is a part of Fig. 2. A pyramid of the GSRTA verification criteria with their quality attributes are supported by the target standard and the evidences from patterns as an input of the process to produce quality verification issues. In this way, we had explored the quality attributes by the identified verification criteria, afterward we declared the verification issues from the quality attribute in supporting of the patterns evidence. The process outcome are questions listed in Table III that will be a treatments in an experimental design in section IV. Each verification criteria had been investigated as follow.
A. Goals

From our previous work [12], goal of patterns creation had been established once we constructed the WSC patterns which is the conformity to the target standard, WSC-UI. In short, the goal achievement was considered *whether the propose patterns conform to the target standard*. As a result, the quality attributes of goal achievement was supported by the sources of knowledge used to develop each pattern. In pattern description part, it explains the purposed of pattern. The verification of this part of all patterns must semantically map to target standard objectives and scope. In order to investigate that the patterns had been built upon this goal, the questions were raised as shown in Table III for goal verification criteria. These issues were intended to test the understanding of the experimental units to the objective of the proposed patterns and target standard.

B. Sources

The proposed patterns had been basically gathered from trusted documented containing security principles and best practices. In our research, trusted source is WSC-UI standard. In order to confirm *whether content of the mentioned sources is functional*, the target standard was determined by a list of questions listed in Table III. These questions were answered by the experimental units using traceability matrix in Table II. Only 2nd column was used for analyzing by security experts whether knowledge proposed in the target standard is suitable for practice and did not conflict with security principles.

C. Representations

Contents of source knowledge were controlled under the patterns representation in term of pattern structure, element, content, and patterns relationships. Therefore, well-formed representation of the patterns influences the understandability for applying the proposed patterns. In this case, the proposed patterns had been presented in the pattern templates which organized by the basic elements depicted in Table I. In additional, the relationship among patterns had shown in Fig. 1. These attributes were used to extract verification issues listed in Table III in order to verify the content representations of the proposed patterns.

D. Transformations

The proposed patterns had been generated from the target standard. Traceability matrix table as shown in Table II was constructed as a tool for backward traceability from the proposed pattern to the target standard. Semantically verification
of content consistency and content completeness between both documents was performed. For each pattern, the content consistency among related elements must be verified. There were two types of consistency checking, 1) between solution part and internal structure part and 2) between problem part and solution part. After analyzing, relevant terms were underlined and bold in the solution part in order to explicitly show that such content must be depicted in the internal structure part as a class name as shown in Table I.

E. Applications

An application criterion is concerned with the content described in an example and exampled resolved part in term of level of clarification explanation and ease of application in the real case since these two parts mainly focus on the issue or problem and the correspondence application. In addition, these two parts must be conformed to the scope of the context and problems. The content of an example of error handling and signaling was shown on Table I. All patterns quality evaluation criteria of the application were listed for expert assessment as shown in Table III.

4. Experimental Design

The objective of the experiment is to verify the proposed patterns using the proposed quality attributes, GSRTA, thru the identified questions list as shown in Table III. In this section, an experiment was planned for collecting relevant data for evaluation. As well as, objects for the verification were defined as follows: units, treatments, and criteria.

A. Experimental Units

The evaluation method is basically based on security expert matter. The security principles and experience need to be concerned in the security patterns verification. In our

Table 3: The Verification Issues Organised By Criteria.

<table>
<thead>
<tr>
<th>No.</th>
<th>Questions List</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Verification Criteria 1: Goals</strong></td>
</tr>
<tr>
<td>1</td>
<td>Level of understanding the importance and objective of the proposed patterns, before and after the experimental explanation.</td>
</tr>
<tr>
<td></td>
<td><strong>Verification Criteria 2: Sources</strong></td>
</tr>
<tr>
<td>2</td>
<td>Level of understanding of the target standard content, before and after the experimental explanations.</td>
</tr>
<tr>
<td>3</td>
<td>Content of the WSC-UI target standard consists with security principles and practices: Section 5 Apply TLS to the Web</td>
</tr>
<tr>
<td></td>
<td>Content of the WSC-UI target standard consists with security principles and practices: Section 6 Indicators and Interactions</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>5</td>
<td>Content of the WSC-UI target standard consists with security principles and practices: Section 7 Robustness Best Practices</td>
</tr>
<tr>
<td>6</td>
<td>Content of the WSC-UI target standard consists with security principles and practices: Section 8 Security Considerations</td>
</tr>
</tbody>
</table>

**Verification Criteria 3: Representations**

<table>
<thead>
<tr>
<th></th>
<th>The structure and elements of proposed patterns are well-organized.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>The suitability of the patterns structure and their components</td>
</tr>
<tr>
<td>9</td>
<td>The ease of understandability of the defined patterns relationships</td>
</tr>
<tr>
<td>10</td>
<td>Contents of the proposed patterns are clearly defined and ease of understanding.</td>
</tr>
</tbody>
</table>

**Verification Criteria 4: Transformations**

<table>
<thead>
<tr>
<th></th>
<th>The content of the source knowledge was completely transformed to the content in the proposed patterns.</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>The consistency between problem and proposed solution for each proposed pattern</td>
</tr>
<tr>
<td>13</td>
<td>UML Class diagram appeared in the internal structure part reflects and covers the content of the solution.</td>
</tr>
</tbody>
</table>

**Verification Criteria 5: Applications**

<table>
<thead>
<tr>
<th></th>
<th>Scenarios of problem defined in the problem part and example resolved part are clearly defined for the application.</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>The context, structure, and patterns’ relationship of the proposed patterns are well-defined and ease of use.</td>
</tr>
<tr>
<td>16</td>
<td>The proposed patterns enhance the understand ability of the target standard for the application.</td>
</tr>
<tr>
<td>17</td>
<td>Benefit for having security concerns of the systems analysis and design.</td>
</tr>
</tbody>
</table>

**Table 4: The Experimental Treatments Grouping.**

<table>
<thead>
<tr>
<th>Group</th>
<th>Experimental Units</th>
<th>Web Security Patterns</th>
<th>Traceability Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group1</td>
<td>4 Persons</td>
<td>51, 52, 53, 61, 71, 72.</td>
<td>Yes</td>
</tr>
<tr>
<td>Group2</td>
<td>4 Persons</td>
<td>51, 54, 64, 71, 73, 85</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Group 3
4 Persons
51, 61, 62, 71, 74
Yes

Group 4
4 Persons
51, 71, 81, 82, 83, 84, 86
Yes

4 Groups
16 Persons
18 Patterns
18 Tables

Experiment, an experimental unit involved 16 master students enrolled in an information security course from normal and weekend program since the participants from normal program has intensively studied full-time course while students from weekend program has experienced in security industrial practice. In our study, experimental units were divided into four groups according to the patterns groups; each group has 4 students from both programs in order that the characteristic of participants were distributed.

B. Experimental Treatments

Web Security Patterns. All patterns were analyzed to specify the common patterns must be used by the others. WSCP-51 and WSCP-71 pattern has been used by the others.

In addition, the related patterns were grouped as shown in Fig. 2. To balance the workload of experimental units, classified to 4 groups, each group was assigned to evaluate a group of relevant patterns with approximately the same number of pages. Each group contained set of patterns as shown in Table IV.

Questionnaires. A list of questions from Table III was organised in 3 parts: overall, patterns, and application. Objective and importance of our work was listed in an overall part. Proposed patterns opinions were asked in patterns part. Application opinions of the proposed patterns were asked in patterns application part. The quality attributes were selected and located for each part according to our experimental purpose. Also, the papers for taking notes and comments are included in a questionnaire booklet.

Traceability Matrix. As defined in Table II, it was used for reference handling for the patterns content and the target standard.

C. Experimental Criteria

The 5-point Likert-scale, a linear scale indicating the extent respondents agree or disagree for each question, is used in our experiment to earn the level of satisfaction of the experimental unit. The score was rated from 5 scored that implies
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strongly agree thru 1 scored implies strongly disagree. Two statistics, Mean and Standard Deviation (SD), were used to evaluate the experiment result.

5. Experimental Execution

Experimental execution was performed according to our plan. The processes began with providing an overview of our research and background of target standard and the proposed pattern. Then, the content of questionnaires was explained to clarify the misunderstanding issues. The experimental units performed their assigned tasks. Then, data collecting, validating and analyzing were executed.

6. Result

The Mean and SD of all samples was 4.35 and 0.22 scores. Almost overall means of all patterns evaluation is above 4. As shown in Fig. 3, the highest average is WSCP-53 pattern with 4.75 scores, while the lowest average score is WSCP-62 with 3.90 scores. This indicated that the proposed patterns had a high degree of satisfaction by the experimental units. However, one of the important feedbacks was the complexity of terms used and their definitions.

We had collect recommendations for each quality attribute. Goal and Source had no recommendation while Representation, Transformation and Application had 7, 7 and 4 respectively. For example, in Representation, there was suggestion about the elements order in pattern structure, such as an Example part should be appeared after a Problem part. In Transformation part, using the provided traceability table, there were some missing links between content in source standard target and the proposed patterns. In Application, some experimental units requested to include additional pictures to help them understand the application visualization. For example, capturing screen content from the real example solved was important for them to realize to the actual situation scenarios.

7. Conclusion and Future Work

This research proposed verification method and criteria for patterns construction using Web Security Context Patterns Case Study in order to improve the quality of the proposed patterns. The two additional verification criteria, Knowledge Transformation and Patterns Application were proposed while three criteria, Goal, Source and Representation were proposed by Breaux (2012). From 5 verification criteria, the quality attributes, Achievement (measuring conformance to the target standard), Functionality (coverage level of including best practices and principles), Understandability (ease of
understanding of patterns structure, relationship and content), Completeness and Consistency (between target standard, patterns and within patterns), and Clarification and Application (clarification of proposed exampled solved and coverage of application situations) were established.

Each verification criteria and their attributes were analyzed to construct a list of questions to be evaluated the case study patterns by experts from both academia and industry. By using these proposed quality attributes, the experimental result shown that WSCP patterns were satisfied by the experimental units in a high level (above 4 from a scale of 5). Moreover, feedback and suggestions from experts help us improve proposed patterns’ content.

In the future, by using the proposed evaluation criteria, the quality of our proposed patterns, web security context patterns, will be in a situation that can be expanded for constructing a set of requirements more efficiently for the ease of patterns application. Essentially, grammars based on patterns contents and their relationships will be created for generating a semiautomatic web user agent requirements specification.

Reference


2. E. Gamma, R. Helm, R. Johnson, and J. Vlissides, Design Patterns: Elements of Reusable Object-Oriented Software, 1995.


