Agile, Web Engineering and Capability Maturity Model Integration: A systematic literature review.☆

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ABSTRACT

Context: Agile approaches are an alternative for organizations developing software, particularly for those who develop Web applications. Besides, CMMI (Capability Maturity Model Integration) models are well-established approaches focused on assessing the maturity of an organization that develops software. Web Engineering is the field of Software Engineering responsible for analyzing and studying the specific characteristics of the Web. The suitability of an Agile approach to help organizations reach a certain CMMI maturity level in Web environments will be very interesting, as they will be able to keep the ability to quickly react and adapt to changes as long as their development processes get mature.
Objective: This paper responds to whether it is feasible or not, for an organization developing Web systems, to achieve a certain maturity level of the CMMI-DEV model using Agile methods.
Method: The proposal is analyzed by means of a systematic literature review of the relevant approaches in the field, defining a characterization schema in order to compare them to introduce the current *state-of-the-art*.
Results: The results achieved after the systematic literature review are presented, analyzed and compared against the defined schema, extracting relevant conclusions for the different dimensions of the problem: compatibility, compliance, experience, maturity and Web.
Conclusion: It is concluded that although the definition of an Agile approach to meet the different CMMI maturity levels goals could be possible for an organization developing Web systems, there is still a lack of detailed studies and analysis on the field.

1. Introduction

Since the establishment of Web Engineering as a separate field of Software Engineering [15], it is recognized that Web-based developments are different from classical software development projects and that its specific characteristics will need a specific treatment [19,21,4,28].

Among other specific aspects, Web systems are characterized by a fluidic scope, a flexible approach to requirements and quick user-feedback [41], due to the need to adapt and adjust to changing requirements [43]. This means that the ability to change is a key success factor in Web applications. Thus, Agile methodologies might perfectly fit Web environments since one of their principles consists in embracing changes [6].

A growing trend towards offering new methods dealing with applying Agile approaches to Web environments started several years ago [3] and different research groups are working on this new line of research [32]. Furthermore, the more popular Web systems become, the more their quality requirements increase.

CMMI-DEV (Capability Maturity Model Integration for Development) is a well-known model that provides organizations with a comparative framework to assess the maturity level reached when developing and acquiring software [13]. The fact of achieving CMMI highest maturity levels relates to product quality improvements [24]. Although there are several proposals for Agile maturity models, CMMI remains by far the most well known maturity model being used by more than 5000 companies all over the world [12].

Thus, an Agile approach to maturity levels based on CMMI could offer organizations developing Web software the opportunity to build quality systems, although keeping their ability to change, as both CMMI and Agile approaches include valid principles for Web software development that are not necessarily incompatible [22].

Even though works regarding the relation between Agile and CMMI started to appear several years ago – we can find papers even from 14 years ago [37] – today both approaches are sometimes

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☆ The views presented on this paper are those of their authors, and do not necessarily reflect those of their employers.
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understood as contrary, as the intense debate among researchers and practitioners shows [16]. Some of the reasons of this mutual reluctance are the bad implementation of both models, the lack of appropriate information and semantic problems [22].

As mentioned above, Web developments require specific treatment and share synergies with Agile approaches. Therefore, and provided that criticisms to Agile methodologies highlight their lack of structure and discipline in comparison with traditional and formal methodologies [8], the possibility of using an Agile approach to reach a certain CMMI maturity level in a Web environment will help institutionalize Agile methods and practices as well as keep the ability to quick response that Agile methods offer to organizations, which is vital in a Web-based development.

Based on the foregoing, this paper aims to cover the following objectives:

- Review systematically the existing literature regarding the relation among Agile methodologies, Web Engineering and CMMI-DEV maturity model.
- Characterize the relevant studies, defining a comparative framework in order to better identify the current *state-of-the-art*.
- Draw relevant conclusions and propose further lines of research.

This paper is organized as follows: After this introduction, Section 2 presents the research method. Section 3 provides the background, including a general idea of Agile methods, Web Engineering and CMMI-DEV together with an overview of the previous existent reviews. Section 4 describes the process carried out to identify and select the studied approaches, as well as offers the comparative framework used to normalize the found approaches. Then, Section 5, based on the defined framework, organizes these approaches by presenting them in a coherent way. Finally, Section 6 analyzes the resultant information and Section 7 states some conclusions and contributions proposing possible future lines of investigation.

2. Research method

This paper aims to be a systematic literature review conducted following the approach proposed by Barbara Kitchenham et al. [26]. The process they recommend comprises the phases below:

1. *Planning the review.* The context and objectives of the review must be delimited to identify the open questions linked to the addressed problems, in order to plan the review. Once they are set, the research questions must be posed as guidelines to cope with the next steps of the process. Finally, the searching protocol is defined with questions such as: "*Which sources will the data be searched in?*" or "*What are the searching criteria and the search strings?*"
2. *Conducting the review.* All relevant approaches are selected and studied according to the constraints described in previous phases. In this phase a common framework is also identified to compare them.
3. *Reporting the review.* A report with the main conclusions obtained is written, after the relevant approaches are selected and studied.

Fig. 1 shows the different phases of the process.

As mentioned, phase 1 consists in the detailed planning of the review. Fig. 2 depicts the process followed during Phase 1 of the review.

Initially, the main research question will be identified and afterwards decomposed in low-level research questions. Based on them, a set of search strings will be defined and the sources to be searched identified.

Phase 2 consists in performing the review as planned in the previous phase and then, defining a characterization schema to better compare the identified studies. Fig. 3 shows the process followed during this phase.
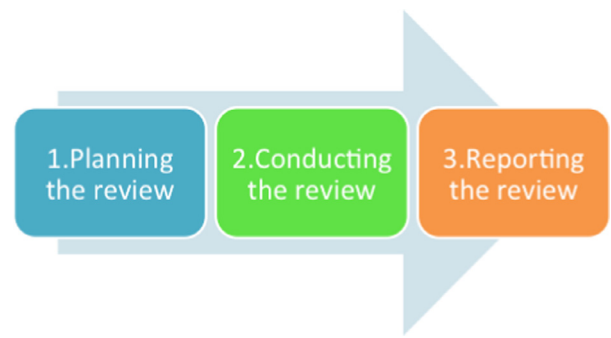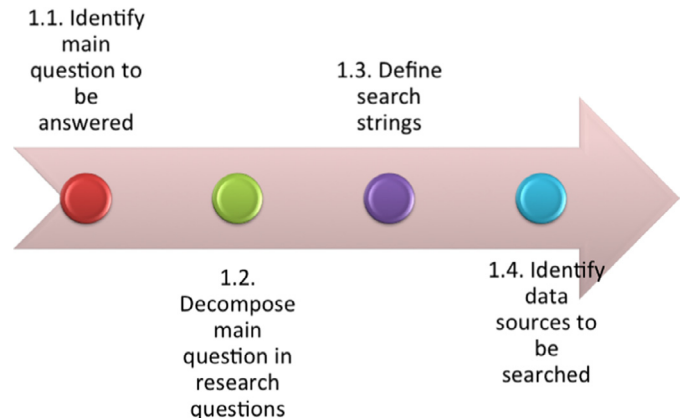

Fig. 1. Systematic review process.

Fig. 2. Phase 1: planning the review.

As shown in Fig. 3, the first step of phase 2 constitutes the initial search and the second one deals with applying a first filter to eliminate duplicated results. The third step is associated with a second screening based on criteria related to the type of paper, date and source of publication.

The fourth step deals with a screening in terms of the title, abstract and keywords, and the fifth one involves the use of a filter according to the full content of the paper. The last phase will consist in the definition of a characterization schema that will allow the comparison of the identified studies.

Finally, the third and last phase consists in drafting a report based on the analysis of the identified papers, extracting relevant conclusions on the defined research questions.

The systematic review reported in this paper tends to clarify the posed problem: *Could an Agile approach help an organization reach a certain CMMI maturity model taking into account the special characteristics of a Web-based environment?*

The following sections will provide an overview of the approaches related to the problem and they will evaluate their degree of maturity to address the previous question.

3. Background and related work

3.1. Agile methodologies

During the last decade of the 20th century, a set of methods and techniques appeared in several software development projects. The main goals of this set of practices were, firstly, to ensure that valuable results were delivered to customers and users as soon as possible, and secondly, to allow development organizations to adapt their products to users' changing requirements [6].

Several years after the appearance of these methods in 2001, some of the most recognized practitioners (Kent Beck, Alistair Cockburn, Martin Fowler, Ron Jeffries, Robert C. Martin, Ken Schwaber and Jeff Sutherland) promoted what was known as the "Agile manifesto" [6],