A NEW SCALED AGILE MATURITY MODEL FOR SOFTWARE DEVELOPMENT PROJECTS

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Abstract- In the fast changing world of software development technologies, the companies are entering the agile transformation process to present fast and better solutions to their customers. As the agile techniques at the team level have produced successful results, scaled agile frameworks have gained importance to make whole organization agile. Because Nexus is the most current agile framework, not a methodology, developed on this field, the level of implementation and knowledge in the industry is less than other scaled agile frameworks. For this reason, the companies in the Nexus adoption process need a gradual and uniform model as a guideline. For this need, this paper presents to the software development companies and the literature a practical and structured maturity model. At the beginning of this study, an existing maturity model was taken as a base model. By the literature review, the initial maturity model was created, then the Delphi technique was carried out to develop and perfect the model by soliciting feedback from the industry experts.

Index Terms- Software development, Nexus framework, Maturity model, Agility, Scaling agile.

I. INTRODUCTION

In order for organizations to survive in fast changing markets, globalized and rapidly changing markets have obliged organizations to be more simple, flexible and agile in order to quickly adapt to the change. Due to the development and transformation processes of these organizations, the management techniques of software development projects have been forced to evolve, especially in project-intensive companies. According to a CHAOS report published in 2009, roughly 70% of IT development projects have resulted in failure, mostly during the software development stage, due to poor communication between the clients and the stakeholders who play a key role in the product development [6]. Moreover, the most important criteria for success according to this report is the inclusion of the clients at every stage of the project. According to the waterfall project management methodology, the project manager plays a great role in communication management and customer needs are clarified at the beginning of the project, which is followed by the design and development stages, thus not allowing for the fulfillment of this criteria; furthermore, this leads to deviations from the initial project budget, schedule and quality criteria. Additionally, in the waterfall model, one stage is completed before moving on to the next and planning, analysis and design stages subsequently follow each other in a linear fashion without returning to the previous stage up until the user acceptance stage. This technique prevents mistakes from being identified early in the process and the use of proactive techniques to take precautionary measures before reaching the final stage [4]. The agile techniques came about as a "solution" to the disadvantages of the waterfall methodology. Despite the sequential design process, the agile techniques follows an incremental approach where developers start off with a simplistic project design, and then begin to work on small modules [3]. In this way, problems are identified and solutions are generated early, thus allowing for the creation of a product that ensures greater customer satisfaction.

The concept of agility, which means continuously improving work and the infrastructure that enables it [17], emerged in 2001 with the agile manifesto which contains the values and techniques regarding agility [2]. Agile methods are techniques that enable quicker and more appropriate responses to customer needs by enabling the delivery of more frequent, smaller, iterative and incremental software developments. DSDM (Dynamic Systems Development Method), FDD (Feature-Driven Development), XP (Extreme Programming), Crystal (Crystal Clear Software Development), Scrum, Kanban and Scrumban are the most frequently used agile techniques [24]-[1].

The concept of scalability has gained importance with the attempts of organizations to assess the success of agile methods in the projects they are implemented and their attempts to expand them within the organization. The scalability can be defined as the property of reducing or increasing the scope of methods, processes, and management according to the problem size [13]. Scalable agile frameworks, which have come about in accordance with the nature of agile methods, enable agile transformations in organizations in which they are fully or partially implemented.
The following scaling agile frameworks have been published in the literature: SoS (Scrum of scrums) by Ken Scwaber in 2004, DAD (Disciplined Agile Delivery) by Scott Ambler in 2007, SAFe(Scaled agile

framework) by Dean Leffingwell in 2008, LeSS(Large Scale Scrum) by Craig Larman and Bas Vodde in 2008, Spotify by Henrik Kniberg and Anders Ivarsson in 2012, Rage (Recipes for Agile Governance in the Enterprise) by Thompson in 2013, and Nexus by Ken Schwaber in 2015. Although the Nexus Framework is the most recent scaled agile framework, it has been widely preferred because it is simple, easy to apply, not diversified according to the number of teams (unlike LeSS) and overlaps to a great extent with Scrum values and practices. Nexus was developed as a framework, and, due to the nature of frameworks, was structured on roles, rules, artifacts and events with the aim of drawing boundaries. On the path to becoming agile, it is necessary for organizations to be aware of their agility level and lay out a step-by-step road map in order to be promoted to higher agility levels. The framework and definitions drawn out by the Nexus Framework do not provide organizations with the implementation strategies and road maps they need. According to a survey made by Gartner [18], agile methodologies could use a maturity model as a roadmap, so software development organizations might explore their processes and reach higher levels of maturity.

In this study, an existing scrum maturity model which was developed to be compatible with CMMI standards, is taken as a base model [27]. The fact that Scrum practices are clearly defined at all 5 stages of this Scrum maturity model ensures comprehensibility and ease of implementation. The Nexus maturity model (MM) that was developed based on this model aims to provide the same clarity and ease of use. Because the Nexus framework is fairly new and has been implemented by a relatively few number of companies, this makes it even more necessary for companies that make use of Nexus to create a guideline in order to be able to adopt the Nexus framework and to develop their own improvement strategies. With this objective in mind, the research question of this paper;
"How should we design a new maturity model for software development organizations to adopt the Nexus framework as a gradual roadmap"

II. BACKROUND INFORMATION

A. Large Scale Agile Development

Upon being successful in small teams located in the same workplace, agile methods and practices are now being adopted in the large scale [21]. Large-scale agile development has come to be identified with various structures and project settings. It typically refers to the development in large teams and/or large multi-team projects that make use of agile principles and practices in an (possibly large) organization [5]. Agile methods are being adopted by more organizations year after year in large settings [20]. This topic has been considered a great challenge by practitioners and researchers who believe that further research is required [21]-[8]. A limited amount of studies (such as [7]-[16]) focus on the challenges and offer direction for large organizations, especially those that are in the process of shifting from traditional approaches, that are endeavoring to scale agile practices. Lindvall *et al*. touch upon the process large companies go through when implementing agile practices in large settings [14]. They reach the conclusion that it is of utmost importance that large organizations adjust agile practices according to their specific needs. The study demonstrates that the biggest difficulty stems not from implementing agile or new practices but rather from establishing cohesion and the appropriate interface between the already existing processes of the organization and these new practices. To address the agility adoption challenge, the formation of a holistic agility framework is necessary, and various scalable agile frameworks have been developed to enable this.

B. Nexus Framework

Nexus is a scaled agile framework that consists of roles, events, and techniques that unite the work of 3-9 Scrum teams which work on a single Product Backlog in order to build and integrated increment that achieves a target. Nexus is consistent with Scrum and its parts will be familiar to those who have worked on Scrum projects. The difference is that more attention is paid to dependencies and interoperations between Scrum teams, delivering one "Done" integrated increment at least every Sprint [22].

The fact that Nexus includes more than one team, requires the creation of separate backlogs for each team, has increments which are integrable, leads to the formation of dependencies between teams, and is difficult to coordinate makes the proper management of processes important. What is essential in the process flow is the collaboration of each individual. As with the Scrum technique, it is crucial for teams to be able to self-organize, to make decisions as a team, and maximize face-to-face communication between team members in order to ensure the success of Nexus. For this reason, it must not be forgotten that all Nexus team members are responsible for the process flow and that it is not managed only by one single individual.
In the Nexus framework, there is only one product backlog for each Product Owner, one Scrum Master and one development team for each Scrum team. Unlike the Scrum, the Nexus framework has a Nexus integration team. This team consists of a product owner, Scrum master and one or more integration team member. This team is accountable for ensuring that an Integrated increment (the combined work completed by a Nexus team) is produced at least every Sprint.

C. Maturity Models for Agility

By the literature research, 40 agile maturity models are found for agile techniques at team management level. Additionally, aside from the maturity model developed for the SAFe, there isn't any model in the literature addressing the practices, objectives and goals of scalable agility for large development organizations.

Because the Nexus Framework is a new model, there is a limited number of experienced individuals in the industry. This limitation compels companies that wish to try out the Nexus framework to apply for coaching services which is a common method in agile transformation journey [9]. The need for an incremental guideline which explicitly defines goals, objectives, practices, and measurement metrics has necessitated the formation of a maturity model, which is the main focus of this study.

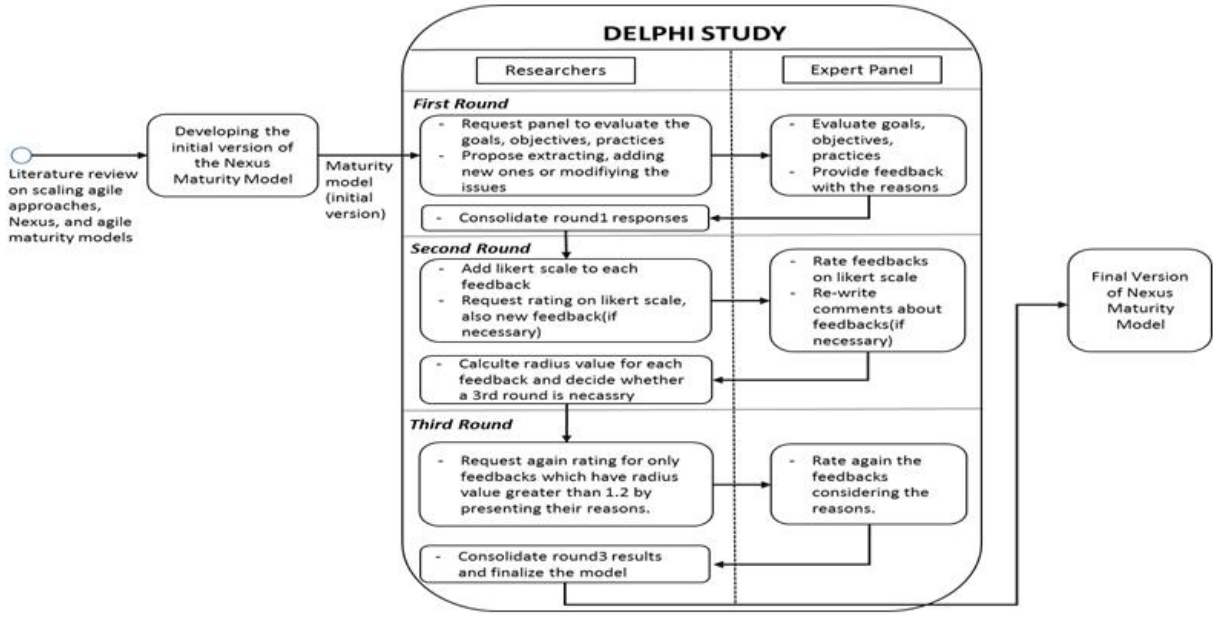


Fig. 1 Research Procedure

III. RESEARCH DESIGN

A design science research approach was adopted in this study which aimed to develop a new maturity model as an agile artifact [10]. In line with this approach, the research design consists of the following: Defining the objectives and problem of the artifact, designing and developing the artifact, evaluating the artifact in actual scenarios [19]. The research procedure to develop Nexus maturity model (MM) is shown in Fig. 1.

A Delphi study was led with seven agile/Nexus experts in order to enhance the relevance of the model put forward and make certain that the content is valid, thus allowing for the perfection and finalization of the model. In this study, three Delphi cycles were conducted because, in order for the relevant practice to be agreed upon, the interval between quarter 3 and quarter 1 (radius=Q3-Q1) must be less than 1.2 [28].

IV. DEVELOPMENT OF NEXUS MATURITY MODEL

Before the Nexus MM was formulated, all agile maturity models compatible with software projects in the literature were analyzed, and the Scrum maturity model developed by Yin *et al*. was determined as the basis of our model for the following three reasons [27]:

- The Scrum MM was inspired by CMMI process area with the mapping of Scrum practices. According to the literature review that was conducted, many studies show that combining agile methods with CMMI is more successful in producing the higher quality software that meets customer needs for more effect at a faster pace [25]-[12]-[15].
- Because the Nexus framework is relatively new, there is a lack of information and experience in the industry regarding the topic; this study aims to contribute to addressing this issue. For this reason, the objectives, goals and practices of the model to be formulated must be laid out in detail at each stage and the practitioners must be provided with the measurement metrics. The base Scrum maturity model provides the necessary details and structure.
- The Scrum MM focuses mainly on the lack of collaboration between the vendor organization and the client side. In the literature review conducted, it was found that one of the biggest risk factors that led to failure was the lack of collaboration between the vendor organization and the client [23].

A. Development of Initial Model

Developed by Yin *et al*., the Scrum maturity model is an artifact which defines the goal, objectives and practices of Scrum in 5 levels and the measurement of these practices. By taking into account the Nexus framework roles, events, definitions and artifacts that were determined through a literature review, some goals, objectives and practices were discarded from the Scrum maturity model, some items were added to the model and some items were modified. As a result of this harmonization study, the initial model is created. If we are to make a numerical comparison, whereas the base model contains 7 goals, 19 objectives, and 82 practices, the initial Nexus MM consists of 7 goals, 22 objectives, and 116 practices.

B. Model Development with Delphi Method

For Delphi study, 7 Nexus and Scrum experts from the sector were determined. 5 of the participants are the individuals who provide consultancy on Scrum and Nexus in different countries.

a. The first round of Delphi study

The aim of the first cycle is to present participants with the initial model and obtain their comments. The participants were asked to comment on the following:

- Whether they believed any goal, objective, or practice in the model should be taken out, and if so, why?
- Whether they believed any additional goal, objective, or practice should be included in the model, and if so, where and for what reason?
- Whether they believed the location or definition of any goal, objective or practice should be changed, and if so, why?
- Whether they had any additional comments regarding the model, and if so, what were those?

All of the comments were compiled in one single document and the reasons for each suggestion for change were listed under the relevant item. A 7-point Likert scale was used to rate the changes and a 7-point scale was placed under each suggestion for change in the document.

b. The second round of Delphi study

The main objective of the second cycle was to attain responses offered by the experts for the model that consisted of the 159 items obtained from the first cycle. At the second cycle, the participants were re-sent the consolidated document and asked to rate the changes on a 7-point scale by taking into consideration the justifications, as well. They were also requested to add any further comments if they had any. Based on the responses, the average value, first quarter, third quarter and radius value of each scored item was calculated. Because the radius values of 5 of the 43 items that were suggested for change, addition, or removal were greater than 1.2, the need to conduct a third cycle arose. At the end of second cycle, the 7-point scales for the relevant 5 items, participant comments, and other items that were agreed upon were consolidated in a single document.

c. The third round of Delphi study

The target of this cycle was to ensure the participants reached a consensus on all of the items and to obtain a source from which the final model could be based on. Thanks to the participants' comments and total scores tallied up for the 5 items, the total radius value was found to be less than 1.2; therefore, the Delphi procedure was completed without the need for a fourth cycle.

d. Refinements after Delphi rounds

In the initial model, there were a total of 77 goals, 22 objectives, and 116 practices; the post-Delphi study consisted of the same number of goals and objectives whereas the number of practices increased to 117. The feedbacks and suggestions for change were based more on definitions and content rather than numbers and were particularly related to the definitions of the practices. Based on the feedbacks from the experts, only one goal was changed.

- The name of the goal "standardized project management" found in the fourth level was changed to “standardized product management” as Nexus is focused on product management.

At the goal level, two goal names were changed:

- At level 3, the goal "definition of done exist" was changed to "successful managing definition of done." The accepted reason is: The existence of this definition is a basic requirement for Nexus and shouldn’t be defined as a goal in Level 3. “The existence of definition of done” should be under level 2, goal 2, objective 2 - Nexus artifacts exist. In level 3, it should be successfully managed.
- At level 4, the goal "quantitative project management" was changed to "quantitative product management" with the reason that Nexus is focused on product management.

The suggestions for change, additions and removals were predominantly related to practices. Here, it is not possible to give a detailed description of the proposals for the 43 practice items because they are great in number.

C. Nexus Maturity Model

When the Nexus MM was being designed, a group of guiding rules was employed to define agile and Nexus practices and properly to disseminate these practices in the right Nexus maturity levels.

- Rule number 1: Each practice must assist in achieving the maturity level objective where it is populated. As an example, the practice "whole team participation" under goal 1 in level 5 serves carrying out the objective "successful daily Scrum."
- Rule number 2: Each objective must contribute to the goal that it is connected to. For example, the objective "successful daily Scrum" found under level 5 must be achieved in order to reach the goal

"performance management".

- Rule number 3: The achievements of the practices populated at higher levels depend on the achievements of practices at lower levels. For example, the achievement of the practice "definition of 'done' completely ensures an integrated product increment" found under goal 1 objective 1 at level 3 depends on the achievements of the practices "definition of done exists" and "integrated product increment exists" under goal 1 objective 2 at level 2.

The ultimate version of Nexus MM that was created as a result of the Delphi cycles is presented in Fig. 2.

D. Assessment of Nexus Maturity Model by Delphi Experts

At the end of Delphi study, whether Nexus MM has enough necessity, practicality and understandability for users, was asked o the experts. All experts agree or strongly agree upon the necessity of new model, they think that this kind of maturity model designing studies provide wide range knowledge to newly developed frameworks, so this Nexus MM is useful for the Nexus framework in terms of being applied easily at more organizations. Also, six experts 'strongly agree' on practicality of Nexus MM, but one of them thinks that this model may be structured on scrum principles not on goals and objectives, then the model can have less practice and this may provide the industry users to apply it easily, but of course not regarding to CMMI standards. This idea can be assessed for future studies to design a new Nexus MM, not compatible with CMMI. Lastly, while 3 experts strongly agree and 2 experts agree, 2 experts neither agree nor disagree on understandability of Nexus MM. These 2 experts believe that any implementer of this model must have Nexus framework knowledge to a certain extent for a better understand.

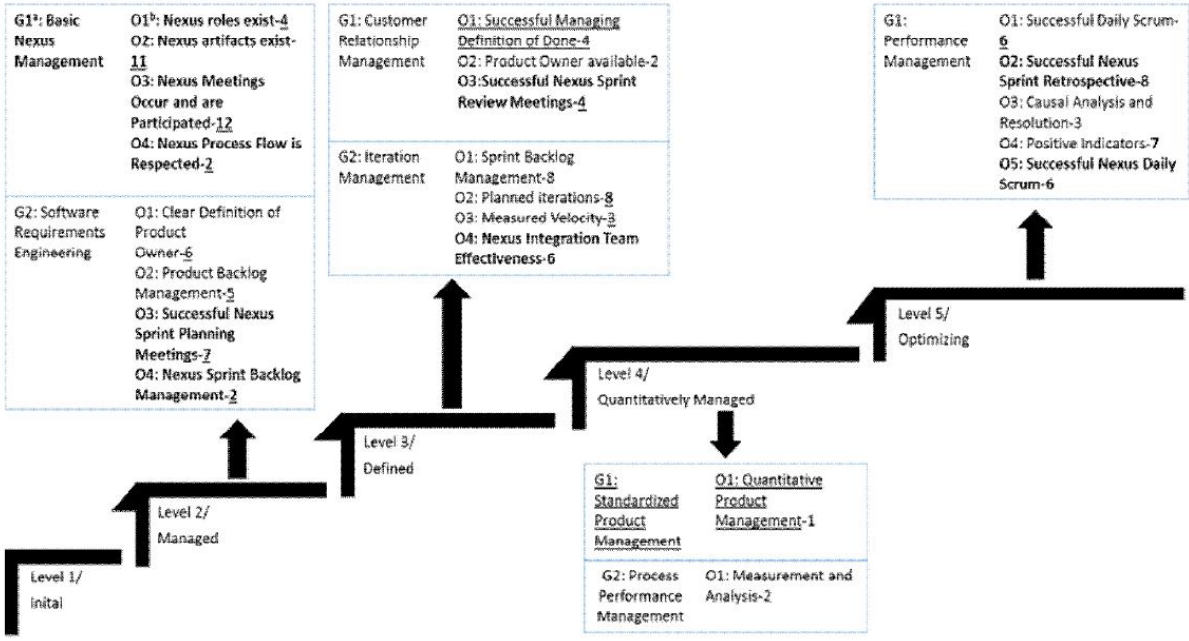


Fig. 2 Final Nexus Maturity Model

Bolded items depict the items that differ from the base Scrum MM; underlined items depict the items being changed or added newly after Delphi cycles. Some items do not stem from the Scrum MM and transformed with the Delphi cycles; these items are both bolded and underlined.

Due to the extent of the material, only the numbers of the practices are showed next to the objective's name. The definition of each practice listed in the Nexus Maturity Model is provided in a supplementary material, available at: http://avesis.yildiz.edu.tr/esincan/dokumanlar

[a] G: Goal, [b] O: Objective

V. LIMITATIONS AND FUTURE DIRECTIONS

There are two limitations in this study. To start off, the layout the Delphi technique we employed to assess the Nexus MM has two major limitations. The first limitation consists of the number of participants who participated in the Delphi study. Although there is no particular ideal number that the literature agrees upon with regards to Delphi study [11], a mere seven participants may be deemed acceptable minimum number for Delphi. To overcome this limitation, in this domain highly competent and experienced experts were worked with.

The second limitation, concerns the fact that feedback rounds were carried out in an anonymous fashion;

although this did allow the experts to re-evaluate their initial opinions without being influenced by other participants, this may have prevented interaction within the group, thus potentially leading to decreased accuracy in terms of group judgments [26]. In order to increase the validity of the collected data, the study was led meticulously at the stages of the panel selection, creating questionnaires, and compiling the views of experts.

As a future direction, because Nexus MM is a new model, the execution some case studies in different organizations would be helpful to develop and improve the model and to explore potential risks behind Nexus adoption.

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