Evaluation of Service-Oriented Architecture Adoption Maturity Model for Sustainable Development

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Abstract—Goal-oriented evaluation is a fundamental approach to monitor and ensure that all measurement activities are being carried out in the context of a well-defined evaluation goal. However, this study found that the previous Service-Oriented Architecture maturity models have not comprehensively considered providing an appropriate method for evaluating the Service-Oriented Architecture adoption. Therefore, this study aims to provide an evaluation method for Service-Oriented Architecture adoption by using goal-oriented approach. The reason is that in order for the evaluation to be effective, it must be driven by a goal. Thus, this study adapts the goal-oriented approach in order to provide an effective evaluation method for evaluating the Service-Oriented Architecture adoption. This study also extends the metric component in Goal-Question-Metric by providing a scale for each metric based on the NPLF rating scale adapted from ISO/IEC 15504. Conclusively, this paper has shown that goal-oriented approach can be used to evaluate the Service-Oriented Architecture adoption through Goal-Question-Metric. Goal-Question-Metric also provides a hierarchical structure that can be refined in order to evaluate the SOA adoption towards a sustainable development effectively. Sustainable development means that the teams work at consistence and continuous speed to produce a quality result. Therefore, the proposed model may benefit the Service-Oriented Architecture practitioner and quality editor in software engineering domain.

Index Terms—Software Engineering; Service-Oriented Architecture Adoption; Sustainable Development; Goal-Oriented Approach.

I. INTRODUCTION

Previously, the majority of the Service-Oriented Architecture (SOA) maturity models have not comprehensively considered to provide an appropriate evaluation method. The evaluation method used in the previous SOA maturity models need further improvement to produce better quality and consistency in the evaluation processes. The model such as SOAMM, SIMM, iSOAMM and Veger's model does not discuss in details on how they come out with their evaluation method. Only Abdul Manan [1] described in their evaluation method where they identified SOA Critical Success Factors (CSF) and constructed the scorecard framework. Nevertheless, they also do not provide a structured and systematic evaluation method where they only rely on the CSFs identified in the literature. Without a proper evaluation method, the process of determining the system merit, worth and significance cannot be effectively executed [2].

Furthermore, systematic evaluation method also is important in order to assess the quality of software used in a software development organization [3].

In addition, past literature has identified that evaluation must focus on a specific goal in order for it to be effective. Basili and Cladiera also supported this claim by stating that the evaluation should be performed in a top-down approach and driven by a specific goal [4]. Ideally, in order to reduce the development cost and to retain focus, the evaluation should be goal driven [5]. Furthermore, goal-driven approaches can provide multiple solutions and choices rather than depending on a single technological approach [6]. The incremental process in goal-oriented approaches also allows the refinement and clarification of the requirements [6].

However, to the best of our knowledge, the previous SOA maturity models did not include the goal-oriented approach for measuring the SOA adoption. As a result, these previous models cannot clearly define the goals and objectives for measuring the SOA adoption. In order to identify the specified evaluation goal, Goal Question Metric (GQM) can be used. GQM has been widely used [7], [8] and can provide a hierarchical structure that consists of three main parts which are Goals, Questions, and Metrics [4]. Therefore, this study found that there is a need to integrate the goal-oriented approach through the adaptation of GQM in order to ensure that all of the activities required in the evaluation processes are being carried out. The adaption of goal-oriented approaches also can contribute towards the sustainable development. Sustainable development means that the teams work at consistence and continuous speed to produce a quality result. Therefore, the proposed model may benefit the SOA practitioners and quality editor in software engineering domain. The structure of this paper is organized as follows: Section 2 and 3 provides an overview of SOA adoption and goal-oriented approach. Section 4 discusses the evaluation of SOA adoption using goal-oriented approach. Section 5 concludes the study with a brief summary.

II. SOA ADOPTION

SOA adoption is a complex process that involves a migration process which can disturb the social and technological structure of organizations [9]. The organization resources (e.g. employee, technology, workflow and etc.) will be affected and a proper organizational redesign (e.g. individual and culture) is

needed in order to adopt SOA successfully. This migration process encompasses the introduction of new technologies, concepts and principles of software development, IT management and IT architecture [10].

The perceived benefits of SOA have promoted SOA as an architecture that capable of addressing the business needs of modern organizations in a cost-effective and timely manner [11]. SOA benefits also have been the major reason why organization adopts SOA. Luthria and Rabhi further mentioned that based on their finding, SOA had been widely adopted because there are many benefits provided by SOA and these benefits also can appear in the form of business strategy and design architecture [12]. There also has been an increasing interest in academia to investigate the approaches for migrating legacy systems to SOA because of the benefits that SOA provided [13]. Still, prior SOA maturity models did not focus on evaluating the SOA based on the benefits that it can provide. The existing models were more focused on the management aspect of SOA such as SOA policy, governance, engineering method and much more [14]. Thus, this study proposed to evaluate the SOA adoption based on the SOA benefits which can be categorized into IT and business benefits. The next section is going to discuss the evaluation method that is going to be adapted in this study.

III. GOAL-ORIENTED APPROACH

Previously, Basili and Cladiera (1994) have stressed that evaluation process should be driven by an evaluation goal in order to be effective. This approach should also be applied to all life-cycle process and deduce based on characterization and understanding of the organizational context, environment, and goals [4]. This means that evaluation must be defined in a top-down fashion and it must focus based on goals. A bottom-up approach is not efficient because there are many visible characteristics of software such as time, number of defects effort and productivity [4]. Furthermore, without the appropriate goals to define the context, it is hard for the evaluator to deduce and determine which metric should be used [4].

The Goal Question Metric (GQM) approach, which was developed by Basili and Weiss and expanded by Rombach, is the most widely used goal-oriented approach [8]. GQM has become a de facto standard for the definition of measurement frameworks [5]. One of the reasons for its success is that it is adaptable to many different organizations and environments, as confirmed by the great number of organizations that have successfully applied it such as Philips, Siemens and NASA [15]. Moving from goals to metrics also has proven to be effective in order to ensure that a relevant measurement was used [16]. However, this study found that there is a lack of works that adapted GQM in the existing SOA maturity models. Thus this circumstance has motivated this study to adapt GQM in order to evaluate the SOA adoption. Figure 1 illustrates the hierarchal elements in the GQM approach.
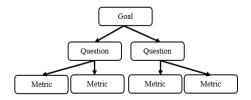
Based on Figure 1, GQM approach consists of three levels which are:

i. GOAL is defined for objects such as processes (designing and testing), products (specification and programs) and resources (hardware and software)
ii. QUESTION is used to refine the goal set up in the conceptual level to characterize the assessment to be performed.
iii. METRICS are identified and answer the question refined in a qualitative way. The data can be objective (for example number of staff, number of documents or size of program) and subjective (for example level of agreement, level of management effort and readability of the document).

IV. EVALUATION OF SOA ADOPTION MATURITY MODEL USING GOAL-ORIENTED APPROACH

This section provides the proposed SOA adoption maturity model evaluation using GQM. Based on the GQM approach, the first step is to construct the 'Goals' for each maturity level. The identified goals in this model are going to be refined into 'Questions' in order to achieve the goal and these questions are then are refined into 'Metrics' which consist of qualitative evaluation. The full hierarchical structure of the proposed SOA evaluation using the GQM approach is shown in Figure 2. Based on Figure 2, goals will be determined for each maturity level. These goals are aligned with the SOA adoption IT and business benefits and for each goal, a set of questions and metrics will be derived. The metrics for evaluating the IT and business benefits will be constructed based on the identified SOA IT and business benefit best practices. However, this study found that the GQM approach did not indicate on how to calculate the score and mapped it onto the maturity levels. Thus, this study will extend the metric component by calculating the score and mapped it onto the SOA adoption maturity level. Figure 3 illustrates the examples of matrix and metrics for evaluating the IT and business benefits.
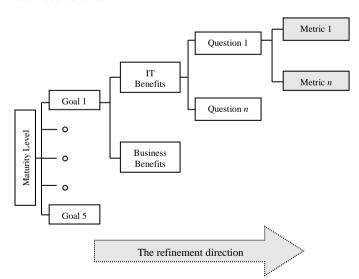
Figure 2: The Structure of the Goal-oriented Evaluation (Adapted from [4])

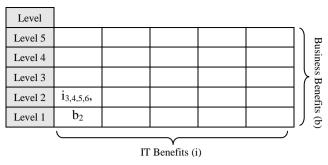Figure 1: Goal Question Metric (GQM) Paradigm

Figure 3: Example of Matrix and Metrics for Evaluating the IT and Business Benefits

Figure 3 illustrates the example of matrix and metrics for evaluating the IT and business benefits. The following Table 1 and Table 2 describes the example of questions and metrics derived from maturity Level 2 (i3,4,5,6, b2) which "i" refer to IT benefits and "b" refer to business benefits.

Table 1
Examples of Questions for Maturity Level 2 ($i_{3,4,5,6}$, b_2)

Questions (Q)		
IT Benefits (i)		
Reusability	i_3	Q1: Is the service provided commonly used?
	i_4	Q2: Is the service provided comply with SOA standard conformance?
	i_5	Q3: Is the service provided comprehensible?
	i_6	Q4: Is the service provided understandable?
Business Benefits (b)		
Cost Reduction	b_2	Q5: Is the service provided have acceptable performance in term of time?
		Q6: Is the service constructed have an acceptable budget in term of development cost?

Based on Table 1, the reusability and cost reduction are the examples of IT and business benefits characteristics that have been identified in this study. For each IT and business benefits characteristics, there are several sub-characteristics that should be fulfilled in order to achieve the IT and business benefits. The example of questions in Table 1 is derived from the SOA IT and business benefits sub-characteristics identified from the previous literature. Then, these questions/sub-characteristics will be refined into metrics presented in Table 2.

Table 2 shows the metrics that are derived from the best practices of SOA IT and business benefits sub-characteristics. Referring to Table 2, this study extends the metric component by providing a scale for each metric/best practice based on the NPLF rating scale adapted from ISO/IEC 15504 [17]. This scale ranged from 0 to 3 where 0 = not achieved, 1 = partially achieved, 2 = largely achieved, and 3 = fully achieved. Then, the score will be calculated for the quality (individual) improvement and the maturity (total) improvement by adapting Weighted Sum Method (WSM). WSM is suitable to use for when all the data are expressed in exactly the same unit. Based on the percentage from the calculation, each factor will be assessed based on the NPLF rating scale, where N = not achieved (0 – 15%), P = partially achieved (>15- 50%), L = largely achieved (> 50 -85%) and F = fully achieved (> 85- 100%) which demonstrate the fulfillment of the SOA process factors. The data obtained from applying these metrics will be formulated as a feedback report to the organization to facilitate them in assessing their maturity level for SOA adoption. The SOA adoption maturity is achieved and can proceed to the next level if the score for maturity (total) improvement is F = fully achieved

(> 85- 100%). Table 3 shows the description of the NPLF rating scale.

Table 2
Examples of Metrics for Maturity Level 2 ($i_{3,4,5,6}$, b_2)

Metrics (M)			Not Achieved	Partially Achieved	Largely Achieved	Fully Achieved
IT Benefits						
Q1	M1	A commonly used and widely applicable functionality and non-functionality of the service to service consumers existed.	0	1	2	3
Q2	M2	A service that conforms to the widely accepted industry standards existed.	0	1	2	3
	M3	Architecture, standardization and protocols are determined.	0	1	2	3
Q3	M4	Interface of a software component that is considered as the protocol and the basis for contracts existed.	0	1	2	3
Q4	M5	Functionality, interface, and constraints in a highly understandable form existed.	0	1	2	3
Business Benefits						
Q5	M6	Technology standards for SOA specification existed.	0	1	2	3
	M7	Service interface to facilitate shorter application development time existed.	0	1	2	3
Q6	M8	Enterprise funding existed and organization are able to proactively fund shared program and technologies.	0	1	2	3
	M9	A single architecture enterprise service bus (ESB) to facilitate the communication between all services existed.	0	1	2	3
	M10	ESB for monitoring and maintaining applications from various platforms existed.	0	1	2	3
	M11	Methods to measure Return on Investment (RoI) and effort in relation to business goals existed.	0	1	2	3

Table 3
NPLF Rating Scale (Adapted from [17])

Rating Scale	Descriptions
Not Achieved (0-15%)	This level indicates unsatisfying level of achievement. The SOA processes were not implemented systematically and below average. The methodology usage was neglected. The SOA process is considered as failure to achieve its goal.
Partially Achieved (>15-50%)	This level indicates a partially satisfying achievement. A systematic approach has been used; however almost all of the assessed SOA processes were not implemented properly.
Largely Achieved (<50-85%)	This level indicates a largely satisfying achievement. The SOA processes were implemented quite systematically. However, some SOA processes of low performance exist.
Fully Achieved (>85-100%)	This level indicates a fully satisfying achievement. The SOA processes were implemented effectively, systematically and perfectly or almost perfectly

V. CONCLUSION

Previous researchers have stated that in order for the adoption of innovation such as SOA to be successful, an organization needs to provide clear and consistent goals [4].

Thus, this study has provided a method for evaluating the SOA adoption by using a goal-oriented approach through GQM. GQM is consist of three main parts which are Goals, Questions, and Metrics. The goal is defined for objects such as processes (designing and testing), products (specification and programs) and resources (hardware and software). Question is used to refine the goal set up at the conceptual level to characterize the assessment to be performed. Metrics are identified and answer the question refined in a qualitative way. GQM also was the most widely used technique and this study adapts the GQM approach for evaluating the SOA adoption due to several reasons. The advantage of the GQM approach is that it provides a systematic approach to formalize the goals of a project and to refine them into a measurement plan [18]. GQM also is a hierarchically structured approach, where the hierarchy of specific criteria and sub-criteria helps the understanding of the problem and simplify the problem by providing a better focus [18].

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