

An Evaluation Method for Service-Oriented Architecture Maturity Model

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Abstract—SOA maturity model was used to clarify and provide a common definition of SOA inside an organization. The model provides an abstract overview of SOA adoption by characterizing evolutionary levels. However, this study found that there is a lacking on how the previous models were evaluated to show that the model is conforming to the specification and can be implemented in the real-world environment. Therefore, this study aims to provide the evaluation method for the SOA maturity model through the verification and validation process. The Integrated Adoption Maturity for Service-Oriented Architecture (IAMSOA) model was chosen and the verification process is being performed through expert review where the study identifies the experts, determines the verification criteria, and collects and analyzes the feedback; while the validation was performed through case study by identifying the organization, determining the validation criteria, brainstorming, and collecting and analyzing the feedback. The verification results show that the evaluated model is comprehensive, understandable, accurate, and well-organized. Moreover, the validation results reveal that it is feasible and practical to be executed in the real environment. Conclusively, this study has successfully evaluated one of the SOA maturity models and shows the verification and validation process in detail which can be re-enacted in different projects and settings.

Keywords—Maturity model; model evaluation; model validation; model verification; service-oriented architecture

I. INTRODUCTION

Google, Microsoft, and Facebook, among others, have grown increasingly reliant on cyberspace for everyday operations. As a result of COVID-19's rapid global spread, demand for internet services has urged in lockstep with the issue [1] [2]. The volume of service requests has increased dramatically in comparison to previous years and some of the firms have taken several significant initiatives, including the adoption of Service Oriented Architecture (SOA). A successful SOA implementation requires a well-defined SOA roadmap that details the plans, milestones, techniques, and desired outcomes. Adopting SOA is a major project that requires numerous organizational changes. Typically, businesses begin by wrapping traditional systems in web services and utilizing SOA as a means of achieving business benefits through total business transformation [3]. The most effective method for handling this shift is to divide it into phases. Adopting a maturity model is the simplest way to implement the transformation roadmap [4].

Additionally, the frequently divergent perspectives of IT, business managers, and organization leaders on SOA maturity adoption and delivery could be the result of unstated assumptions about where and why SOA should be adopted [5]. Furthermore, auxiliary work in SOA metrics is also required. Researchers are encouraged to continue developing maturity models using a combination of qualitative and quantitative metrics. A model of SOA maturity must consider both perspective and execution maturity. Progress must also be accomplished in a three-dimensional environment, with the shift from an IT-driven to an enterprise-transformation perspective — encompassing governance, performance indications, drivers, and even nomenclature, which therefore will likely eclipse execution enhancements inside a given perspective.

Nevertheless, even though numerous scholars contributed to the development of the SOA maturity model, there is still a dearth of effort in evaluating the model at the time of writing. This study has found that it is important to evaluate the model to show that it conforms to the standard specifications and is suitable to be implemented in a real-world setting. Moreover, based on the previous literature, this study has identified various SOA maturity models that have been constructed, such as SOAMM, SOASMM, Governance Maturity for SOA, and IT Risk Management Maturity Model for SOA [6, 7, 8, 9]. Yet, most of the previous models did not discuss in detail how they evaluate their models to prove they are of high quality and can produce reliable results. Based on the literature reading, the IT Risk Management Maturity Model for SOA is one of the few models that highlights the importance of evaluating the model through a case study approach. A similar finding has also been mentioned in other maturity models set up in the Global Software Development (GSD) domain, where they state that the case study approach is a powerful evaluation tool that can provide valuable real-world information [10].

However, relying solely on the case study approach to determine that the developed model conforms to its specifications and that all of the required components are present in sufficient quantity is inadequate [11]. It is critical to obtain the domain expert's approval and feedback before sanctioning the developed model [12]. Therefore, this study proposed including both the expert review (verification) and case study (validation) approach within the evaluation process. In realizing this approach, it was determined that one of the SOA maturity models should be evaluated to determine whether the constructed model meets the specifications,

captures the requirements needed, and can be implemented in a real-world environment. Accordingly, the Integrated Adoption Maturity for Service-Oriented Architecture (IAMSOA) model was chosen and evaluated through the verification and validation approaches. This study is structured as follows: Section I covers the introduction and is followed by Section II (the background of the study). Section III discusses the methodology applied in this study and Section IV presents the results. Section V discusses the verification and validation results and Section VI summarizes the study.

II. BACKGROUND OF THE STUDY

SOA maturity models provide an abstract overview of SOA adoption by characterizing evolutionary levels [13] [14]. They can be thought of as a collection of critical process areas that work together to optimize a well-defined business and IT architecture. They also can be used to regulate and measure the progress of SOA adoption [15]. In addition, SOA maturity is one of the most pressing challenges of SOA adoption issues in the SOA lifecycle [16]. However, theoretically sound, methodologically rigorous and empirically evaluated SOA maturity models are extremely rare [17]. As a result, this study determined the importance of reviewing and discussing many of the most widely used SOA maturity models presented by the industry and academia. The aim of the study is to determine how the current researchers evaluate their proposed SOA maturity model.

The SOA Maturity Model (SOAMM) was published in 2005 based on the feedback from around 2000 architects and developers [6]. SOAMM maturity levels were evaluated through a single evaluation dimension that incorporates various perspectives, including prime business benefits, scope, critical technology success factors, critical people success factors, organizational success factors, and selected relevant standards. Based on these perspectives, they presented a guide for establishing SOA vision and a benchmark for measuring progress by including the goals, characterization of the scope, business benefits, important industry standard, key practices, and critical success factor. Despite this, SOAMM never explained how they evaluate their model in depth.

In 2012, Welke et al. [14] proposed an SOA maturity model based on the capabilities of maturity model integration (CMMI). Welke's model first interpreted their maturity model as a capability orientation model, and then they specified that as SOA becomes more mature, the SOA ability should be fully realized in order to contribute to business operations and organization's service orientation as a whole. Furthermore, the researcher proposed an SOA maturity cube that introduces the idea of a multidimensional view for SOA maturity. The first dimension is for the organization to identify their current levels of SOA maturity according to six defined SOA criteria, which are the infrastructure efficiency, reuse, composition and integration, business process and analytics, enterprise flexibility and agility and enterprise transformation; the second dimension is to determine what to do in order to reach the next maturity, which are the benefits and metrics, business involvement, methodology, service sourcing and governances. However, their study also does not include a comprehensive discussion on the evaluation method.

Inspired by the introduction of the SOA maturity model in 2005 [6] and the maturity cube concept by Welke et al. [14], Hamzah et al. [18] first presented that the SOA should have prioritized on both information technology (IT) and business benefits. Then, continuing their work, they mentioned that the SOA maturity level should be based on the Adoption of Innovation theory to cater for SOA adoption issues and that the GQM approach should have been included within the evaluation matrix to provide a structure and systematic evaluation [19] [20]. Additionally, they did an exploratory study in 2019 to bolster and enhance their findings, which subsequently lead to the introduction of the IAMSOA model. Nonetheless, their work is incomplete, as they emphasize the importance of evaluating their model to conform that it can accomplish the desired objective and being employed in a real-world setting.

Coincidentally, within the same year of 2019, another researcher has performed a systematic literature review on the SOA maturity models to identify research opportunities and areas where the SOA maturity model can be improved [21]. A total of 20 unique SOA Maturity Models were investigated and reviewed in detail. Their findings reveal that although all SOA Maturity Models propose an assessment framework, only a few SOA Maturity Models are guided in prioritizing the improvement process. Furthermore, in line with this study's interest, they also mentioned that empirical research on the in-depth analysis and evaluation of SOA Maturity Models is sparse. They also further acknowledged that there is minimal effort in evaluating the SOA maturity model and it is critical for future research to work on this issue.

Recently in 2021, Azevedo et al. [9] constructed an IT Risk Management Maturity Model for SOA. This work presents a risk management maturity model, formed by the union of good information technology risk management practices and existing maturity models, to be applied in an SOA. The model aims to support the assessment process of identifying the level of risk management maturity within the SOA domain. To evaluate the proposed model, the scenario of a health organization was used, and the results indicated that the level of IT risk management maturity based on SOA was measured, providing a holistic view of risk management on the dimensions of people, processes, and technology. They stated unequivocally that it is important to validate the SOA maturity model through a real-world scenario in which their results show the risks maturity level and the importance of managing risks properly.

As a result of earlier literatures, this study concluded that it is important to perform the evaluation on the SOA maturity model, particularly through the implementation in a real-world environment. The proposed evaluation method through the verification and validation process is expected to provide an organized guideline for other researcher to evaluate their developed SOA maturity model. This study will build on the work of [20] by conducting an evaluation of the IAMSOA model via the verification and validation process. The approach utilized in this study to evaluate the IAMSOA model is described in the next section.

III. THE EVALUATION METHOD FOR SERVICE-ORIENTED ARCHITECTURE MATURITY MODEL

Based on the literature reading, this study has found that the evaluation for SOA maturity model should be performed through two main phases which are the verification and validation phases. Fig. 1 shows the proposed evaluation method for SOA maturity model and the components require to perform the evaluation process. They are discussed further in the next subsection.

A. Verification Stage

The verification should be performed to check whether the SOA maturity model conforms to its specification [22] and ensures that all required components are present in the right quantity [23]. This study found that the verification stage was intended to verify i) the maturity level, ii) evaluation dimension, and iii) evaluation matrix. To accomplish these aims, the expert review should be used because it has been accepted as a significant way to detect and remove defects [24]. Basically, there are three activities involved in verifying the SOA maturity model which are i) identifying the expert, ii) determining the verification criteria, and iii) analyzing the feedback. These activities are discussed in the following subsections.

1) *Identifying the expert:* The experts should be chosen among the academicians (knowledge experts) by following the characteristics of experts as suggested by Hallowell and Gambatese [25]. The characteristics include i) currently attached to the field of the study under examination, ii) hold an advanced degree (PhD.), iii) faculty members at an accredited university, iv) authorship, and v) have at least five years of experience. Additionally, as the SOA maturity model is intended to be used by the SOA practitioners, therefore, they should be included as the domain experts to perform the verification as well as to give their insights from the real-life

environment point of view. The characteristics of the domain experts are that they should have at least three years of experience in SOA implementation.

2) *Determine the verification criteria:* The study has identified that the major components of the SOA maturity model are the maturity level, evaluation dimension, and the evaluation matrix. These components should be verified for their comprehensiveness, understandability, accurateness, and organization. These criteria were based on the previous studies where it was appropriate and has been successfully used to verify their model or framework [26] [27]. The questions that were asked to verify and measure these criteria were adopted from Salah [28].

3) *Collecting and analyze the feedback:* The knowledge expert's feedbacks should be collected and analyzed for further improvements.

B. Validation Stage

Models validation is a fundamental process to confirm that the models are of sufficiently high quality [29]. In this context, the validation process was performed to prove that the SOA maturity model have high quality and can be re-enacted in other projects or settings. This study performed the validation process through the case study approach. The details activities for the validation process are discussed in the next subsection.

1) *Identifying the organization:* The organization should be selected based on their dealing with SOA, the available projects related to the SOA, and their willingness to apply the model. The study also identified that it is appropriate to select the organization according to their expertise in dealing with SOA where the organization needs to be competent in SOA-based applications. This enables the testing of the feasibility and practicality of the model in different settings.

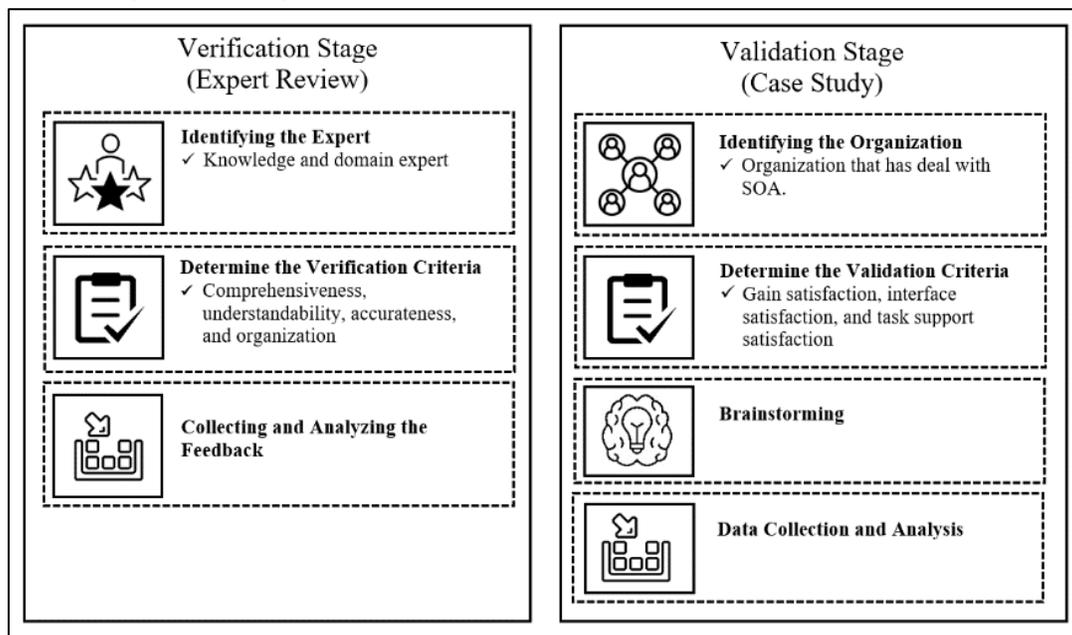


Fig. 1. The Proposed Evaluation Method for SOA Maturity Model.

2) *Determine the validation criteria:* The validation criteria for the SOA maturity model were determined by adapting them from the study of [25] which can reveal the success of the proposed model. Kitchenham and Pickard [30] stated that the evaluation criteria should include three main criteria which are, gain satisfaction, interface satisfaction, and task support satisfaction. These common criteria had then been used by several researchers such as [20] and [19] in evaluating their model or framework which were carried out in the field of software engineering.

3) *Brainstorming:* After the identification of the validation criteria, the validation process should be performed. The brainstorming session should be conducted where it is to introduce the SOA maturity model to the organization. The purpose of implementing the SOA maturity model should be explained to the organization who participate in this validation process.

4) *Data collection and analysis:* The data collection and analysis can be performed by giving out and collecting the data based on two evaluation forms which are: i) the proposed instrument in order to evaluate the maturity of SOA adoption for the organization and ii) the evaluation form to validate the proposed model. Based on the feedback from the organization, the data should be analyzed and the evaluated SOA maturity model should be improved.

IV. THE IMPLEMENTATION OF THE PROPOSED EVALUATION METHOD FOR SERVICE-ORIENTED ARCHITECTURE MATURITY MODEL

This section is going to discuss the result of implementing the proposed evaluation method to the IAMSOA model.

A. Result for Verification

This section illustrates the experts' answers and suggestions for the IAMSOA verification. There are three major components of the IAMSOA model which need to be verified by the experts which are the evaluation dimension, maturity level, and evaluation matrix. These components were verified based on their comprehensiveness, understandability, accurateness, and organization. These criteria were adapted from previous studies [24] [26].

The experts provided their feedbacks by filling in the checklist form. The experts were asked to rank the level of these criteria achievement. The Six Likert scales were used to describe the level of achievement of the items. The results were calculated by getting the mean score for each criterion and selecting the appropriate interval that represents the actual mean. Table I shows the mean interval presentation and the achievement level adapted from ISO 15504 while Table II reveals the verification results for the evaluation dimension components.

Results in Table II show that three out of four criteria gained "fully achieved" for the evaluation dimension which are comprehensiveness, understandability, and well-organized. The accuracy is the only criteria that gained 'largely achieved'. Most of the experts stated that the evaluation dimension is well defined and acceptable.

TABLE I. REPRESENTATION OF ACHIEVEMENT LEVELS (ADAPTED FROM ISO/IEC 15504)

Mean Interval Presentation	Achievement level
From 0 to 0.8 (0%-15%)	Not achieved
From 0.9 to 2.9 (>15%-50%)	Partially achieved
From 3 to 5 (>50%-85%)	Largely achieved
From 5.1 to 6 (>85%-100%)	Fully achieved

TABLE II. VERIFICATION RESULTS FOR THE IAMSOA EVALUATION DIMENSION

Item	Mean	Overall Mean	Achievement Level
Comprehensiveness			
The required criteria for evaluating the SOA IT and business benefits are included.	5.3	5.3	Fully Achieved
The required sub-criteria for evaluating the SOA IT and business benefits are included.	5.3		
Accuracy			
The IT and business benefits criteria and sub-criteria are correctly assigned to maturity levels.	4.9	5	Largely Achieved
There is no overlap detected for the descriptions of IT and business benefits criteria and sub-criteria.	5.1		
The sub-criteria for IT and business benefits are correctly assigned to IT and business benefits criteria.	5		
Understandability			
The IT and business benefits criteria and sub-criteria are understandable.	5.2	5.2	Fully Achieved
The IT and business benefits criteria and sub-criteria descriptions are understandable.	5.2		
Well-Organized			
The IT and business benefits criteria are well organized.	5.3	5.25	Fully Achieved
The IT and business benefits sub-criteria are well organized.	5.2		

Expert F mentioned that at the 'Optimized' level, the organization should be looking at the agility and flexibility for optimization and transformation to be ahead of the competition. Furthermore, another expert (Expert C) stated that the proposed model needs to consider a few KPAs such as Configuration Management. In short, all of the experts agreed with the evaluation dimension of the IAMSOA by stating that the proposed dimension is acceptable and can be applied to measure the IT and business benefits. As for the IAMSOA maturity level verification, the results are listed in Table III.

TABLE III. VERIFICATION RESULTS FOR THE IAMSOA MATURITY LEVEL

Item	Mean	Overall Mean	Achievement Level
Comprehensiveness			
The number of maturity levels are adequate and appropriate.	5.2	5.08	Fully Achieved
The maturity levels description is sufficient.	5.3		
The maturity levels are sufficient to represent all maturation stages of the domain.	5		
The Key Process Area (KPA) for each maturity level covers all aspects for evaluation of the domain.	4.8		
Accuracy			
There is no overlap detected between descriptions of maturity levels.	5	5.13	Fully Achieved
There is no overlap detected between each Key Process Area (KPA) of maturity levels.	5		
The Key Process Areas (KPAs) are correctly assigned to their respective maturity level.	5.4		
Understandability			
The maturity levels are understandable.	5.3	5.2	Fully Achieved
The maturity levels description are understandable.	5.2		
The Key Process Areas (KPAs) for each maturity level are understandable	5.1		
Well-Organized			
The maturity levels are well organized.	5.2	5.15	Fully Achieved
The Key Process Area (KPA) for each maturity level are well organized.	5.1		

As shown in Table III, the maturity level gained “fully achieved” for all the criteria. Based on the expert review, majority of the experts satisfied with the proposed maturity level. One of the experts mentioned that the maturity level for the IAMSOA model is derived from a well-defined standard in software engineering practices such as CMMI and it is well understood. Another expert also stated that the maturity level is well organized and understandable. Conclusively, all the experts agreed that the IAMSOA maturity level is well-defined, organized, and appropriate to be used as a benchmark for measuring the SOA maturity and adoption. Table IV presents the results of the IAMSOA evaluation matrix verification.

TABLE IV. VERIFICATION RESULTS FOR THE IAMSOA EVALUATION MATRIX

Item	Mean	Overall Mean	Achievement Level
Comprehensiveness			
The model is sufficient to determine the SOA adoption maturity	5	4.92	Largely Achieved
The model is sufficient for conducting SOA adoption process improvement	5		
The model is sufficient to track the SOA adoption issues	4.7		
The model is sufficient and practical to be used in industry	4.9		
The model is useful to be used in industry	5		
Accuracy			
The overall evaluation matrix are constructed correctly	5.1	4.98	Largely Achieved
The evaluation goals are constructed correctly	5		
The evaluation questions are constructed correctly	4.9		
The evaluation metrics are constructed correctly	5.1		
The evaluation process are constructed correctly	4.8		
Understandability			
The evaluation matrix is understandable	5.3	5.2	Fully Achieved
The evaluation process is understandable	5.3		
The implementation guideline is understandable	5		
The scoring scheme is understandable	5.2		
Well-Organized			
The structure of evaluation matrix are well organized	5.4	5.3	Fully Achieved
The evaluation process are well organized	5.2		

Based on Table IV, two out of four criteria for the IAMSOA evaluation dimension gained “fully achieved”. The criteria that obtained “fully achieved” are understandability and well-organized, while the comprehensiveness and accuracy criteria “largely achieved”. Expert E commented that detail descriptions for the achievement scale (not achieved, partially achieved, largely achieved, and fully achieved) are required and the coverage for the evaluation needs to be included. Moreover, Expert A mentioned that the evaluation matrix needs to include specific steps such as an evaluation flow for the evaluation matrix to be clearer and understandable. Another expert (Expert C) also stated that there are a few steps in the assessment process that need to be rearranged where some of the steps should appear at the beginning of the assessment process. Nevertheless, despite some of their comments, all the

experts agreed that the evaluation matrix for IAMSOA is well structured and can be applied in the real-world environment.

Overall, all experts gave general reviews of the proposed IAMSOA model. They concluded that IAMSOA is a good model and can benefit the industry. Majority of the experts agreed that IAMSOA is a flexible model that can be extended to cater other related SOA domains. Finally, once the evaluation dimension, maturity level, and evaluation matrix have been verified, the validation process were performed and is presented in the next subsection.

B. Result for Validation

The aim of the validation process is to evaluate the effectiveness of the IAMSOA model. In this study, the validation was performed through case study. This section presents the results of the case study conducted in one of the software companies in Malaysia. The aim is to validate the IAMSOA model and show its applicability and added benefits. Fig. 2 shows the assessment process flow for SOA maturity model.

The case study was performed by assessing the Product Inspection System by Company A. Detail discussions for the case study are presented in the following subsection.

1) *Organization profile:* Company A is an in-house solution provider. Its main client is an electric utility company

that represents one of the large semi-government sectors in Malaysia. Apart from providing a centralized, one-stop center for technical solutions and innovation, Company A has developed some solutions under a variety of applied research projects. Recently, Company A needed to ensure that only qualified equipment is employed by their parent company. In order to provide this service, a Product Inspection (PI) Management System was developed by the company. This signifies that the PI has an enormous job coordination. To handle such big volumes, a flexible architecture is necessary to ensure that the PI Section is able to manage various PI related works. Hence, the SOA has been adopted in developing the PI Management System. In addition, a mechanism to measure the quality of the SOA-based application is required to ensure the delivery of high-quality services to the IT and business people in the company. Having the SOA-based application, it is obvious that the IAMSOA model can help in determining the level of adoption and maturity. After contacting and discussing with the company’s ICT Research Unit, the proposed IAMSOA model was used to assess the SOA adoption maturity for the PI Management System. The subsequent sections describe the details of the IAMSOA model related processes in evaluating and assessing the SOA adoption maturity in the company.

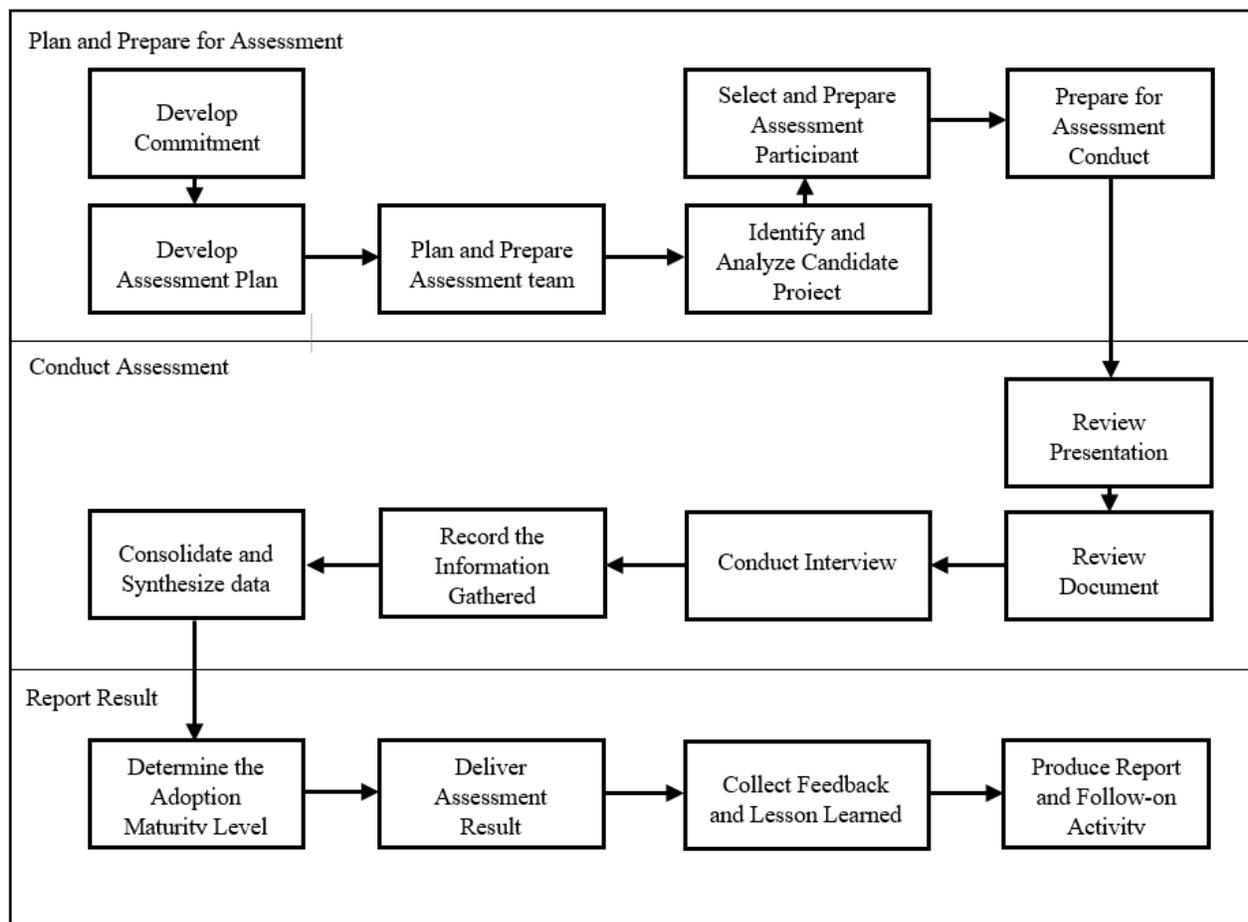


Fig. 2. SOA Maturity Model Assessment Process Flow.

2) *Plan and prepare for assessment process:* There are six activities involved in the planning and preparing for the assessment process; i) developing commitment, ii) developing assessment plan, iii) planning and preparing assessment team, iv) identifying and analyzing project candidate, v) selecting and preparing assessment participant, and vi) preparing assessment conduct. During this phase, the assessment team in Company A started to plan and prepare for applying the IAMSOA model. The phase started by defining the objectives, constraint, and scope for appropriate assessment design as well as establishing an organization leader commitment. Then, the team prepared a document for guiding and defining the execution of the assessment. The lead assessor, conducted a briefing session to the team to familiarize them with the assessment plan, IAMSOA model, and assessment process. After the briefing, the team continued with a meeting among its members to discuss whether the assessment can be conducted or not. After they agreed to proceed with the assessment, each staff was appointed a specific role.

3) *Conduct assessment process:* After finishing the first activity, the assessment team continued to conduct the assessment. The assessment processes include i) reviewing presentation, ii) reviewing document, iii) conducting interview, iv) recording the gathered information, and v) consolidating and synthesizing data.

This phase began when the assessor started to collect the data by participating during the staff/developer’s presentation regarding SOA project. The assessor then assessed the

documents produced during the development of the project. The assessor also interviewed the top management, project manager, and developers to obtain information about the project/system and clarify on any information that could not be acquired through document review. Then, the assessor produced a document that records all the gathered information. After obtaining all the required data, the assessor went on to calculate the score for individual and overall performance qualities of the SOA project by using the IAMSOA assessment form as shown in Fig. 3.

4) *Report result process:* The final phase is about reporting the results that involved four activities; i) determining the adoption maturity level, ii) delivering assessment results, iii) collecting feedbacks and lesson learned, and iv) producing report and supporting follow-on activity. At the beginning of this phase, the SOA adoption maturity level for Company A was determined based on the score extracted from the IAMSOA assessment form. The results of the maturity level for the PI Management System is presented in Tables V, VI, VII, and VIII. Table V shows the score for the PI Management System at Maturity Level 1 is 95% which indicates that the PI Management System has successfully achieved maturity level 1.

Table VI shows the score for the PI Management System at Maturity Level 2 of 91.5%. This indicates that the PI Management System has successfully achieved maturity level 2.

KPA	Practices	Score			
Awareness Knowledge	The information related to SOA are pursued actively.	1	2	3	4
	The developers are provided with enough SOA reading materials such as literature, book or magazine.	1	2	3	4
	A central knowledge portal for collecting and distributing information related to SOA is established.	1	2	3	4
	Understanding of SOA are shared among the top management, IT division, and business division.	1	2	3	4
	Business division is encouraged to view SOA as a business tool and not just a technology.	1	2	3	4
	The goals of applying SOA are clarified by the top management with the business division.	1	2	3	4
	SOA success stories are gathered and verified with proof of concept and shared throughout the organization.	1	2	3	4

Scoring Guideline: 1 - Not Achieved, 2 – Partially Achieved, 3 – Largely Achieved, 4 – Fully Achieved

Fig. 3. Example of the IAMSOA Model Assessment Form.

TABLE V. MATURITY LEVEL 1 FOR THE PI MANAGEMENT SYSTEM

Key Process Area	Key Practices	Individual Quality	Overall Quality	Achievement
SOA Knowledge Gathering (SOAKG)	Awareness Knowledge (AK)	85%	95%	>85% Achieved Maturity Level 1
	How-to Knowledge (HK)	90%		
	Principle Knowledge (PK)	100%		
New Functionality (NF)	Perform New Service (PNS)	100%		
	Develop Pilot Project (DPP)	100%		

TABLE VI. MATURITY LEVEL 2 FOR THE PI MANAGEMENT SYSTEM

Key Process Area	Key Practices	Individual Quality	Overall Quality	Achievement
SOA Adoption (SOAA)	SOA Adoption Decision (SOAAD)	100%	91.5%	>85% Achieved Maturity Level 2
	SOA Infrastructure Management (SOAIM)	85%		
	SOA Best Practices Management (SOABPM)	95%		
	SOA Project Planning (SOAPP)	87%		
	Service Integration (SI)	Service Modularity (SM)		
Service Scalability (SS)	Service Migration (SMi)	87%		
Cost Reduction (CR)	Time Management (TM)	87%	91.5%	>85% Achieved Maturity Level 2
	Cost Management (CM)	96%		

Table VII shows the score for the PI Management System at Maturity Level 3 of 93.5%. This shows that the PI Management System has successfully achieved maturity level 3.

TABLE VII. MATURITY LEVEL 3 FOR THE PI MANAGEMENT SYSTEM

Key Process Area	Key Practices	Individual Quality	Overall Quality	Achievement
SOA Implementation (SOAI)	Technical Assistance Resolution (TAR)	96%	93.5%	>85% Achieved Maturity Level 3
	Service Analysis (SA)	87%		
	Service Design (SDES)	89%		
	Service Development (SDEV)	93%		
	Service Monitoring (SMo)	100%		
Service Reusability (SR)	Service Publicity (SP)	100%	93.5%	>85% Achieved Maturity Level 3
	Service Conformance (SC)	100%		
	Service Comprehensibility (SCo)	100%		

	Service Understandability (SU)	100%	91.5%	>85% Achieved Maturity Level 2
Service Integration (SI)	Service Availability (SAv)	91%		
Service Flexibility (SF)	Service Reliability (SRe)	91%		
Service Agility (SA)	Service Modifiability (SMod)	100%		
Service Scalability (SS)	Service Replication (SRe)	100%		
IT/Business Alignment (ITBA)	Orchestration Management (OM)	91%		
	Resources Alignment (RA)	85%		

Table VIII shows the score for the PI Management System at Maturity Level 4 of 77.4%. This indicates that the PI Management System has not achieved maturity level 4.

TABLE VIII. MATURITY LEVEL 4 FOR THE PI MANAGEMENT SYSTEM

Key Process Area	Key Practices	Individual Quality	Overall Quality	Achievement
SOA Performance Evaluation (SOAPE)	Service Level Agreement (SLA)	95%	77.4%	<85% Not Achieved Maturity Level 4
	System Testing (ST)	100%		
Service Reusability (SR)	Service Discoverability (SD)	83%		
	Service Commonality (SCom)	92%		
	Service Composability (SComp)	75%		
	Service Portability (SP)	62.5%		
Service Flexibility (SF)	Service Adaptability (SAd)	62.5%		
	Service Interoperability (SInt)	42%		
	Service Changeability (Sch)	55%		
Service Agility (SA)	Service Evolvability (SEv)	75%		
Business Quality (BQ)	QoS Assurance (QoSA)	95%		
	Security Management (SM)	92%		

Results from the evaluation show that the PI Management System has achieved “Maturity Level 3”. Maturity level 5 Key Process Area was marked with ‘pending’ once the Company A failed to achieve Maturity Level 4. Based on Table VIII, Company A can instantly identify at which Key Process Areas and Key Practices that they have been lacking off. Therefore, it is important for Company A to be able to measure the relative maturity within each Key Process Area to identify areas that are lacking.

As presented in Table VIII, at maturity level 4, the PI Management System partially achieved the Service Flexibility, and largely achieved the Service Reusability and Service Agility. Thus, Company A needs to give more attention and work on these Key Process Areas to achieve the next level which is Maturity Level 4. Once the lagging Key Process Areas have been identified, it is possible to come up with solutions and eventually improve the success of the overall SOA initiative.

Based on the results presented in Tables V, VI, VII, and VIII, Company A can determine which goal that the PI Management System has already achieved according to the IAMSOA model. The goal achievement is important to identify the areas that are already fulfilled and those that need improvement. After determining the SOA adoption maturity, the assessment results were immediately presented to the company’s ICT Research Unit to get an agreement on the outcomes. In addition, based on the results, recommendation on future improvements were proposed. Company A has to improve three main service areas, namely Flexibility, Reusability, and Agility in order to achieve Maturity Level 4 and to progress to the next level Maturity Level 5.

V. DISCUSSION

The results indicate that Company A has achieved maturity level 3 and implies that Company A is competent in applying the SOA based-application. Moreover, an interview session was conducted with the assessment team leader for Company A to validate the IAMSOA model. The team leader answered the validation form that was constructed based on a set of evaluation factors. These factors are gain, interface, and task support satisfactions. Each factor includes various related items or statements. These statements were answered by the assessment team members by deciding whether to AGREE or DISAGREE. This type of answers format signifies a practical measurement [31] that can directly capture the respondent’s intention effectively. Table IX displays the validation results form.

From Table IX, the first criterion or factor to be evaluated during the validation process is “gain satisfaction” that measures the benefit of the IAMSOA model to the real-life environment. The measurement items for this factor include decision support satisfaction, comparison with the previous model, clarity, and task appropriateness. The results from the interview point out that the assessment team from company A stressed that the model achieved decision support satisfaction by helping the organization to decide on well-defined processes. The assessment team also agree that the model is very clear and understandable where each process presents the required input, outputs, methods and activities.

TABLE IX. VALIDATION RESULTS

Item	Company A
Gain satisfaction	
Decision support satisfaction: The IAMSOA model helps the management to take a well-defined decision based on the processes.	Agree
Comparison with the previous SOA model: The IAMSOA is better than the old model that you used in terms of structure and achieved results.	Agree
Clarity (clear and illuminate the process): The IAMSOA process is clear to the development team, where each phase clearly presents the required inputs, outputs, methods or practices, and activities.	Agree
Task Appropriateness: The phases and activities presented in the IAMSOA model are appropriate for adopting and implementing SOA in your company; and the flow of the process is presented in a systematic and effective way.	Agree
Interface satisfaction	
Internally consistent: The IAMSOA model is internally consistent.	Agree
Organization (well organized): The components of the IAMSOA model are well organized and structured which makes the process easy to perform.	Agree
Appropriate for audience: The IAMSOA model is appropriate for the audience. Those audiences are referred to the development and the monitoring team in the software firms.	Agree
Presentation: The results presented by performing the IAMSOA process are produced in a readable and useful format.	Agree
Task support satisfaction	
Ability to produce expected results: The IAMSOA model is able to produce expected results.	Agree
Completeness (adequate or sufficient): The IAMSOA model is adequate and sufficient for adopting and implementing SOA in your organization.	Agree
Ease of implementation: The process of the IAMSOA model is easy to implement.	Agree
Perceived usefulness	
Using IAMSOA model enables you to accomplish your tasks more quickly.	Agree
Using IAMSOA model improve the performance of your work.	Agree
Using IAMSOA model makes performing your tasks easier.	Agree
IAMSOA model is useful to your work.	Agree
Using IAMSOA model increases your productivity.	Agree
Perceived ease of use	
Learning the IAMSOA model is easy for you.	Agree
Do you find it easy to use IAMSOA model to do what want to do?	Agree
The IAMSOA model is flexible to interact with.	Agree
Your interactions with the IAMSOA model are clear and understandable.	Agree
It is easy for you to become skillful in using the IAMSOA model.	Agree
The IAMSOA model is easy to use.	Agree

The “interface satisfaction” represents the second criterion or factor that measures the IAMSOA model in terms of interface presentation, format, and processing efficiency. Pertaining to this factor the assessment teams emphasized that the model is internally consistent whereby each component complements one another. The team also agreed that the IAMSOA components are well organized and structured by sorting all the processes, activities, and roles in a clear and understandable manner. The model is also declared to be appropriate for the audience as the team members comprised of those with variety of skills. The team also satisfied with the readable and useful results format produced based on the IAMSOA model.

To ensure that the IAMSOA model can achieve its intended purpose and satisfies the assessor, the “task support satisfaction” factor is used as the third measurement factor. The team also agreed that the IAMSOA model can produce the expected result because it provides a well-defined sequence of activities and a wide variety of evaluation criteria such as the SOA adoption, maturity, IT, and business benefits. In addition, the model was found to be adequate and sufficient in determining the level of SOA adoption maturity that focuses on the IT and business benefits. Consequently, based on the responses relating to perceived usefulness and ease of use, it can be concluded that the IAMSOA model is useful, easy to use, effective, and feasible to be used in Malaysian organizations.

VI. CONCLUSION

This study has presented the evaluation method for the SOA maturity model through the verification and validation stages. The significance of the proposed evaluation method within the domain of the study is to provide a guideline for other researchers who want to ensure that their SOA maturity model conforms to the specification and can be implemented in the real-world environment. The IAMSOA model was chosen as a case study to implement the proposed evaluation method for the SOA maturity model. In the verification stage, the IAMSOA model has been verified by five knowledge and five domain experts. The experts were asked to verify the IAMSOA evaluation dimension, maturity level, and evaluation matrix. Next, the validation stage was performed using the case study approach, and the findings reveal that the IAMSOA model is feasible to be implemented in the real world based on several real-life applicability evaluation criteria such as gain satisfaction, interface satisfaction, task support satisfaction, perceived usefulness, and perceived ease of use. Conclusively, this study has successfully evaluated one of the SOA maturity models through the verification and validation process. Moreover, this study has contributed to explaining how to perform the expert review and case study to evaluate the SOA maturity model. The detailed process, methods, results, and discussion have been presented, and this can guide other researchers to perform the evaluation of their models in other settings.

Nevertheless, this study also identified that there is a limitation to the proposed evaluation method, which requires future work towards enhancing this study. The limitation is that the proposed method involves collaborative assessment where

organizations form a team to assess the maturity of their SOA-based applications. Based on the assessment results, Company A achieved maturity level 3 in their first assessment. The achievement of maturity level 3 for the first assessment is considered high compared to the CMMI assessment (third-party assessment). The high achievement might relate to the collaborative assessment whereby the assessment was performed by its own staff, which may cause biased assessment. Another reason may relate to the practices for the assessment being too general. Thus, in the future, a third-party assessor can be brought in, and the practices should be changed to make the results more reliable and high-quality.

ACKNOWLEDGMENT

The authors would like to thank the Ministry of Higher Education Malaysia for supporting this research under Fundamental Research Grant Scheme Vot No. FRGS/1/2020/ICT03/UTHM/03/1 and partially sponsored by Universiti Tun Hussein Onn Malaysia.

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