

A Construction of Service-Oriented Architecture Adoption Maturity Levels using Adoption of Innovation Concept and CMMI

Mohd Hamdi Irwan Hamzah^{1,2}, Fauziah Baharom¹, Haslina Mohd¹, and Mohd Hasbullah Omar¹

¹*School of Computing, Universiti Utara Malaysia, 06010 UUM Sintok, Kedah, Malaysia.*

²*Faculty of Computer Science and Information Technology,
Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Johor, Malaysia.
hamdi@uthm.edu.my*

Abstract—The existing Service-Oriented Architecture (SOA) maturity models constructed their maturity level focuses on the level after the implementation of SOA in the organization. However, less work has been carried out regarding the SOA maturity level that focused on the whole process of SOA adoption including the pre-adoption level. Furthermore, this study also found that less work on constructing the maturity levels for measuring the SOA adoption existed. Therefore, this study aims to construct the Service-Oriented Architecture adoption maturity level by combining the adoption of innovation concept with Capability Maturity Model Integration (CMMI). This study constructs the lower level of the proposed SOA adoption maturity level based on the adoption of innovation concept and the upper level based on CMMI and the existing SOA maturity models. This study has successfully shown that the adoption of innovation concept can be combined with CMMI in order to construct a holistic maturity level for evaluating the SOA adoption. This level covers the whole SOA adoption processes ranging from the pre-adoption level up to the optimized level. This study also aims at evaluating the SOA adoption toward sustainable development. Sustainable development means that the teams work at consistence and continuous speed to produce a quality result. Thus, the proposed maturity level may benefit the SOA practitioner and software quality assurance in software engineering domain.

Index Terms—Software Engineering; Service-Oriented Architecture Adoption; Sustainable Development; Maturity Level.

I. INTRODUCTION

Researchers have identified that the adopter of innovation must pass through a sequence of levels in order to adopt new services or idea [1]. There are three main levels which are ‘Initiation’, ‘Adoption’ and ‘Implementation’. The ‘Initiation’ process is an activity that associated with the identification of needs, the awareness on the innovation and the evaluation of innovation that will lead to the ‘Adoption’ process. In the ‘Implementation’ process, the adapter should initially use the innovation, continue to use it until it becomes a ‘Routine’ features and modify the innovation in order to optimize it [2].

Commonly, the existing Service-Oriented Architecture (SOA) maturity models constructed their maturity level based on Capability Maturity Model Integration (CMMI). The models such as Service Oriented Architecture Maturity Model (SOAMM), Independent Service Oriented Architecture Maturity Model (iSOAMM) and Welke’s Model

also separate their maturity level into two parts, where the lower levels measure the technical perspective of SOA and the higher levels measure the enterprise adoption of SOA [3], [4]. Abdul Manan argues that the separation of the maturity levels is not appropriate because the technical and enterprise implementation should not be separated and should belong to one category [4]. Furthermore, there are other researchers who stated that most of the previous maturity level focused on measuring the capability of an organization to implement SOA [5] and do not specifically evaluate the maturity of SOA adoption [6].

Generally, the term ‘adoption’ in SOA is related to the Adoption of Innovation concept. However, based on the review, there is a lack of work by the previous researchers that consider employing the Adoption of Innovation concept in constructing the maturity level. Most of the previous SOA maturity model focused on constructing their maturity level based on CMMI level [5]. Veger’s Model was the only model that adopts the Adoption of Innovation concept, yet the maturity levels did not include the service performance evaluation which is important for SOA continuous improvement [3], [7]. The previous researcher also argues that Veger’s Model was developed only to identify the pattern of SOA adoption by an organization (Abdul Manan, 2013). Thus, there is a need to combine the adoption of innovation concept with CMMI and come out with an SOA maturity level that covers the whole process of SOA adoption. This study also aims at evaluating the SOA adoption toward sustainable development. Sustainable development means that the teams work at consistence and continuous speed to produce a quality result. Therefore, the proposed maturity level may benefit the Service-Oriented Architecture practitioner and software quality assurance in software engineering domain. The structure of this paper is organized as follows: section II, III and IV discuss the adoption of innovation, SOA adoption, and maturity model. Section V shows the construction of SOA adoption maturity level by combining the adoption of innovation concept with CMMI. Section VI concludes the study with a brief summary.

II. ADOPTION OF INNOVATION

The ‘adoption of innovation’ is a concept that contributes to the organization’s effectiveness and competitiveness by adapting its practices to new conditions in its external environment [2]. The term ‘adoption’ also refers to the

decision to make full use of an innovation [8]. According to Rogers, innovation levels consist of the complete process ranging from the decision to start on solving a potential problem, decided to adopt, implementation and consequences [9].

Furthermore, there are others who also have identified the adoption of innovation levels. Frambach and Schillewaert identified that the ‘adoption process’ is a sequence of levels that a potential adopter of innovation must pass through before the acceptance of a new product, service or idea [1]. Frambach and Schillewaert also identified that there are three main levels which are Initiation, Adoption, and Implementation [1]. The Initiation level indicated that the organization has been aware of the innovation and start to evaluate whether the innovation is worth to adopt. The Adoption level is where the organization has made the decision whether to adopt or reject that innovation. The implementation level is where the organization chose to purchase and utilize the innovation within the organization. Still, this study found that the adoption of innovation concept did not focus on the level after the implementation of innovation part. Researchers have stated that the innovation process can only be considered a success when the innovation is accepted and integrated into the organization and the target adopters demonstrate commitment by continuing to use it until it is fully optimized [2].

III. SOA ADOPTION

SOA adoption is a process of migrating the legacy system into a service-oriented based application. Previously, many organizations have successfully adopted SOA and the reason why they choose to adopt SOA is that of the benefits that it can provide [10]. Thus, this has inspired this study to focus on why organization adopts SOA which is because of the benefits and this study found that these benefits can be categorized into two major benefits which are Information Technology (IT) and business benefits [11]. The IT benefits are concerned with the design principles of SOA and the business benefits help organization for better planning in order to achieve their business objective.

However, this study found that there is lack of works that construct the SOA maturity levels focus on the SOA adoption. The existing SOA maturity models such as SOAMM, SIMM, iSOAMM and Welke’s model constructed their maturity levels focus on the level after the implementation of SOA within the organization. The pre-adoption level is neglected by the previous models. Thus, this circumstance has motivated this study to investigate and explore the maturity levels constructed in CMMI and the previous SOA maturity models. The maturity level constructed in the previous SOA maturity models are basically based on CMMI and the maturity level is focus on the level after the implementation of SOA by an organization. The next section is going to discuss the concept of maturity which is first introduced by Capability Maturity Model (CMM) and CMMI.

IV. MATURITY MODEL

A maturity model is a tool that facilitates internal or external benchmarking while also presenting future improvement and providing guidelines through the evolutionary process of organizational development and

growth [12]. Maturity model provides a possibility to plan and control software evolution as they allow evaluating the current maturity and identifying current shortcoming [13]. Furthermore, maturity model also can be represented as a scale for evaluating the current state of maturity and depicting the target state of maturity [14].

The concept of maturity model originates from the Capability Maturity Model (CMM) [4], [15], [16]. CMM as the most known maturity model contains essential elements of effective processes [7]. In the year 2002, a new version of the CMM also known as Capability Maturity Model Integration (CMMI), was proposed by Software Engineering Institute. The focus changed from pure software practices towards the integration of systems and software practices. CMMI consists of a set of guidelines that when applied can improve the overall structuring, processes of the organization. It is a framework that supports organizations to develop their process [17]. Maturity levels are defined as evolutionary plateaus of process improvement, which help to predict the future performance of an organization by describing the range of expected results [7]. The CMMI defines six capability levels in the continuous form such as shown in Table 1.

Table 1
Capability Maturity Model Integration (CMMI)

Maturity Level	Maturity Level
1	Performed
2	Managed
3	Defined
4	Quantitatively Managed
5	Optimized

Generally, it is a known fact the quality of a process will determine the quality of a product. There have been a number of organizations that have applied CMMI and ISO/IEC 15504 in order to improve their software processes. The reason is that process assessment has been identified as the main mechanism to determine the capability of a process outcome. The weaknesses, strength and related risks of a process can be identified in the process assessment [18]. Still, CMM, CMMI and ISO/IEC 15504 are used for measuring the maturity of ICT processes, whereas SOA maturity models are used for measuring the maturity of organizational architectures and their capabilities to implement SOA [4]. Contrasting to CMMI, previous researchers identified that SOA maturity model is not limited to a generic software process [4].

However, according to the previous researcher, existing SOA maturity model was constructed from the industry point of view and less of empirical works have been done in this domain [4], [19]. The existing SOA maturity models also focused on evaluating the capability of an organization that implements SOA, rather than evaluating the maturity of SOA adoption by the organization [15]. Furthermore, the existing models also lack attention for the automation of business processes using IT. Therefore, these circumstances have motivated this study to construct an SOA maturity level by combining the adoption of innovation concept with CMMI in order to provide an appropriate level to evaluate SOA adoption.

V. METHODOLOGY

This section discusses the strategy that is used in order to propose the SOA adoption maturity level in this study. Table

2 shows the comparison of the adoption of innovation level identified by the previous study together with CMMI maturity level and the existing SOA maturity level.

Table 2
Comparison of the Adoption of Innovation Level, CMMI Level and SOA Maturity Model Level

Resources		Adoption Level			
Adoption of Innovation Concept	Adoption of Innovation Concept Level [9]	Initiation	Adoption	Implementation	Continue until fully optimized the innovation
	Hage and Aiken (cited in [2])	Initiation		Implementation	Routinization
	Zaltman et al. [20]	Knowledge Awareness Attitude formation	Adoption decision	Implementation	Continued-sustained implementation
	Kanter (cited in [2])			Transfer Utilization	Diffusion
	Roberts (cited in [2])				Diffusion
	Tornatzky and Fleischer (cited in [2])		Adoption	Implementation	Routinization
	Rogers [9]		Adoption		Diffusion
	Klein and Sorra (cited in [2])	Awareness Selection	Adoption	Implementation	Routinization
	Angle and Van de Ven (cited in [2])			Implementation	
	Damanpour and Wischnevsky [2]	Initiation	Adoption	Implementation	
SOA Maturity Model	Nagy [21]	Awareness Evaluation	Adoption		Routinization Infusion
	CMMI [7]		Initial	Managed Defined	Quantitatively Managed
	SOAMM [22]		Initial Architected	Business service Collaborative service	Measured service
	SIMM [14]	Siloed	Componentized	Composite services	Virtualized
	Veger Model [15]	Integrated Siloed Experimental	Simple service Applied	Integrated	Institutionalized
	iSOAMM [13]		Trial SOA	Integrative SOA Administered SOA	Cooperative SOA
	Welke Model [3]		Initial	Managed Defined	Quantitatively Managed
	Proposed Maturity Level for SOA Adoption	Initial	Adopted	Implemented	Evaluated
					Optimized
					Optimized

Table 2 shows the adoption of innovation concept levels, CMMI levels and SOA maturity model levels identified in the previous literature. There are three main levels provided in the adoption of innovation concept which is the Initiation, Adoption, and Implementation. These three levels cover the process where first the adopter is aware and becomes attuned to the existence of the innovation [21], then the adopter will make the decision whether to adopt or reject the innovation and the adopter will implement that innovation. Based on Table 2, the adoption of innovation concept provides the earliest level towards the adoption of innovation. The initial level focus on the awareness, knowledge, and understanding of the innovation that the adopter chooses to adopt. However, this study found that the adoption of innovation concept is lacking in providing a level toward fully optimized the innovation. There is no clear level that indicates the innovation has been fully optimized by the adopter of the

innovation. This circumstance is contradicting with the adoption term where it refers to the decision to make full use of an innovation [9], [23].

In addition, previous literature stated that CMMI and the existing SOA maturity models are more focus on the implementation process onwards [24]. Most of the models provided the optimized level where this level indicated that the adopter has fully optimized the innovation. Therefore, based on the adoption of innovation concept, CMMI, and SOA maturity models, this study proposed that the maturity level of SOA adoption should consist of five (5) levels which are: Initial, Adopted, Implemented, Evaluated and Optimized. These five maturity levels are going to assess the initial process even before the adoption of the innovation until fully optimized the innovation. Table 3 shows the details of the proposed SOA adoption maturity level in this study.

Table 3
The Proposed Maturity Level for SOA Adoption

Level	Focus	Description	Requirement	Resources
Initial	SOA learning	<ul style="list-style-type: none"> This level indicates that organization start to learn about the SOA on what, how and why. Awareness-knowledge (clearly understand what is SOA) How-to-knowledge (know how to apply SOA) Principles-knowledge (why your organization choose to adopt SOA) 	<ul style="list-style-type: none"> Identify the SOA concept. Provide SOA training. Identify the effectiveness of SOA adoption. 	[2], [9], [21], [20], [25]
		<ul style="list-style-type: none"> At the end of this level, organization evaluate whether to adopt or reject SOA. 		
Adopted	SOA adoption	<ul style="list-style-type: none"> This level indicates that organization has chosen to adopt SOA and started to apply the SOA best practices. Services are integrated using an open standard technology (e.g. web service standard) with a common middleware such as ESB. SOA adoption begins to show a return on investment. 	<ul style="list-style-type: none"> Specify SOA best practices. Identify the IT and business benefits. Specify that SOA adoption begin to reduce the development cost. 	[2], [9], [20], [21] [25], [26]
		<ul style="list-style-type: none"> This level indicates that organization has shifted from the IT-focused management of services towards a service driven by business. 	<ul style="list-style-type: none"> Specify the IT and business alignment. 	
Implemented	SOA IT and business alignment	<ul style="list-style-type: none"> Services are self-contained, independent, flexible and ready for business process orchestration. Services are driven by business requirements and defined in business functionality terms. Service definition is now directly tied to business requirements capture, and SOA becomes an effective means to support data analytics and business process redesign. 	<ul style="list-style-type: none"> Ensure that services are business driven. Identify the business process modeling tools, business orchestration servers and business process rules. 	[2], [9], [20], [21] [25], [26]
		<ul style="list-style-type: none"> This level indicates that organization has successfully measured the service performance and agreed upon the Service Level Agreement (SLA). 	<ul style="list-style-type: none"> Identify the team to access the performance of business services. 	
Evaluated	SOA performance evaluation	<ul style="list-style-type: none"> Composite business services are measured and modified for better performance, flexibility and re-use. The organization should be able to achieve the agreed SLA using appropriate infrastructure and the measured performance metrics. Organization has provided a metrics to evaluate the efficacy of new or modified services and relate these to organizational Return on Investment (RoI). 	<ul style="list-style-type: none"> Identify the mechanism to access the performance of business services. Specify the SLA between service provider and consumer. Prove that SOA has provided RoI. 	[3], [7], [26]
		<ul style="list-style-type: none"> This level indicates that organization has successfully realized the full benefits of SOA (IT and business benefits). 		
Optimized	SOA continuous improvement	<ul style="list-style-type: none"> Service can be composed during runtime using externalized policy, description, management and monitoring. 	<ul style="list-style-type: none"> Provide a dynamic-reconfigurable service. Provide a semantic oriented modeling and dynamic application assembly. 	[3], [7], [22], [26]
		<ul style="list-style-type: none"> Services can be dynamically reconfigurable and respond automatically to change during runtime. The process of optimization moves outside the organization along value-chain lines that range from upstream suppliers and downstream clients. 	<ul style="list-style-type: none"> Ensure that service are event driven. 	

VI. CONCLUSION

This study has successfully provided a maturity level for SOA adoption by combining the adoption of innovation concept and CMMI. The maturity level constructed in this study focus on assessing the maturity of SOA adoption rather than the capability of the organization to provide SOA. The maturity level also is aligned with the term 'adoption' where it refers to the recognition that a need exists and moves towards searching for solutions, then to the initial decision to adopt the innovation and finally to the decision to proceed with the implementation of the solution until it is fully optimized [2], [8]. Thus this study found that the adoption of innovation concept is appropriate to be used as an underlying structure to construct the lower level of the proposed SOA adoption maturity level; whereas the upper level should be based on CMMI and the other SOA maturity models where they focus on the level after the implementation of SOA. Therefore, this circumstance has motivated this study to combine the adoption of innovation concept with CMMI and

come out with an SOA maturity level that covers the whole process of SOA adoption ranging from the pre-adoption level up until the optimized level.

ACKNOWLEDGMENT

The authors wish to thank the Ministry of Education, Malaysia for funding this study under the Long Term Research Grant Scheme (LRGS/bu/2012/UUM/Teknologi Komunikasi dan Infomasi).

REFERENCES

- [1] R. T. Frambach and N. Schillewaert, "Organizational innovation adoption: A multi-level framework of determinants and opportunities for future research," *J. Bus. Res.*, vol. 55, no. 2, pp. 163–176, 2002.
- [2] F. Damanpour and J. Daniel Wischnevsky, "Research on innovation in organizations: Distinguishing innovation-generating from innovation-adopting organizations," *J. Eng. Technol. Manag. - JET-M*, vol. 23, no. 4, pp. 269–291, 2006.
- [3] R. Welke, R. Hirschheim, and A. Schwarz, "Maturity," *Computer (Long. Beach. Calif.)*, vol. 44, no. February, pp. 61–67, 2011.

- [4] M. Abdul Manan, "Developing a framework and a scorecard method to measure the enterprise – wide SOA implementation readiness of an organisation," University of Wollongong, 2013.
- [5] S. Pulparambil and Y. Baghdadi, "A Comparison Framework for SOA Maturity Models," *2015 IEEE Int. Conf. Smart City/SocialCom/SustainCom*, pp. 1102–1107, 2015.
- [6] N. Joachim, F. Schlosser, D. Beimbom, and T. Weitzel, "Does SOA Create or Require IT / Business Collaboration? Investigating SOA 's Potential to Reduce the Gap Between IT and Business," *Thirty Second Int. Conf. Inf. Syst.*, pp. 1–19, 2011.
- [7] CMMI Product Team, "Capability Maturity Model ® Integration (CMMI SM), Version 1.1," no. August, pp. 1–645, 2002.
- [8] N. Joachim, D. Beimbom, P. Hoberg, and F. Schlosser, "Examining the organizational decision to adopt service-oriented architecture (SOA) - development of a research model," *Digit 2009 Proc.*, vol. 4, 2009.
- [9] E. M. Rogers, *Diffusion of innovations*. 1995.
- [10] Y. Baghdadi, "SOA Maturity Models: Guidance to Realize SOA," *Int. J. Comput. Commun. Eng.*, vol. 3, no. 5, pp. 372–378, 2014.
- [11] N. Joachim, "A Literature Review of Research on Service- Oriented Architectures (SOA): Characteristics , Adoption Determinants , Governance Mechanisms , and Business Impact," *Am. Conf. Inf. Syst.*, pp. 1–11, 2011.
- [12] T. Mettler, "Maturity assessment models : a design science research approach," *International Journal of Society Systems Science*, vol. 3, 2011.
- [13] C. Rathfelder and H. Groenda, "ISOAMM: An independent SOA maturity model," *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, vol. 5053 LNCS, pp. 1–15, 2008.
- [14] H. Kreger, T. Carrato, A. Arsanjani, A. Szakal, J. Diaz, and K. Holley, "IBM Advantage for Service Maturity Model Standards," no. August, pp. 1–22, 2009.
- [15] M. Veger, "A stage maturity model for the adoption of an enterprise-wide service-oriented architecture (SMM-SOA): a multicase study research," p. 93, 2008.
- [16] F. Meier, "Service Oriented Architecture Maturity Models : A guide to SOA Adoption," University of Skovde, 2006.
- [17] S. Mishra, S. Mazumdar, and D. Suar, "Place attachment and flood preparedness," *J. Environ. Psychol.*, vol. 30, no. 2, pp. 187–197, 2010.
- [18] N. Ehsan, A. Perwaiz, J. Arif, E. Mirza, and A. Ishaque, "CMMI / SPICE based Process Improvement," in *2010 IEEE International Conference on Management of Innovation and Technology (ICMIT)*, pp. 859–862, 2010.
- [19] L. Lasrado and R. K. Vatrappu, "Maturity Models Development in IS Research: a Literature Review," *Proc. 38th Inf. Syst. Res. Semin. Scand. (IRIS 38)*, no. August 9-12, 2015.
- [20] G. Zaltman, R. Duncan, and J. Holbek, *Innovations and Organizations*. Wiley, New York, 1973.
- [21] D. Nagy, "Understanding organizational adoption theories through the adoption of a disruptive innovation: Five cases of open source software," *ProQuest Diss. Theses*, vol. Ph.D., 2010.
- [22] C. Sonic Software, Corporation; AmberPoint, Inc.; BearingPoint, Inc.; Systinet, "A new Service-Oriented Architecture (SOA) Maturity Model." 2005.
- [23] J. Schelp and S. Aier, "SOA and EA - Sustainable contributions for increasing corporate agility," *Proc. 42nd Annu. Hawaii Int. Conf. Syst. Sci. HICSS*, pp. 1–8, 2009.
- [24] S. Pulparambil and Y. Baghdadi, "SOA maturity model a frame of reference," in *2016 IEEE Students' Conference on Electrical, Electronics and Computer Science*, 2016, pp. 1–6.
- [25] J. P. Wisdom, K. H. B. Chor, K. E. Hoagwood, and S. M. Horwitz, "Innovation adoption: A review of theories and constructs," *Adm. Policy Ment. Heal. Ment. Heal. Serv. Res.*, vol. 41, no. 4, pp. 480–502, 2014.
- [26] S. Inaganti and S. Aravamudan, "SOA Maturity Model," *BPTrends*, no. April, pp. 1–23, 2007.