A Priority Based Enterprise Architecture Implementation Assessment Model: An Analytic Hierarchy Process (AHP) Approach

Nur Azaliah A.Bakar, Harihodin S., Nazri Kama
Advanced Informatics School (AIS), Universiti Teknologi Malaysia, 54100,Kuala Lumpur.
nazaliah2@live.utm.my

***Abstract*—Despite of many Enterprise Architecture (EA) frameworks and methodologies available, in reality EA implementation is a challenging process. In order to assure a progressive EA implementation, assessment and monitoring mechanism is required. The existing EA assessment approaches are mostly based on checklist or maturity model and designed to assess post EA implementation. Less EA assessment is found to cater on the pre and during EA implementation process. This indicates that the lack of systematic assessment mechanism, especially for pre and during EA implementation phase. Hence, based on the gap identified, this study proposes a priority based assessment model for pre and during EA implementation process. This integrated model of Balanced Scorecard (BSC) and Analytic Hierarchy Process (AHP) is designed to assess the priority and capability of the organization in implementing EA. The assessment criteria were formulated from findings of an exploratory study. Six main criteria and 27 sub-criteria have been identified as the Critical Success Factors (CSFs) in EA implementation. Based on these CSFs, a Priority based EA Implementation Assessment Model (PEAIAM) has been formulated and presented in this paper.**

***Index Terms*—Enterprise Architecture (EA); Analytic Hierarchy Process (AHP); Balanced Scorecard; Assessment.**

I. INTRODUCTION

Enterprise Architecture (EA) is a hierarchical approach used to align and unify the business process and Information Technology (IT) in an organization. EA analyzes an organization all the way from its generic strategic components to its detailed IT infrastructure. EA is a practice that investigates areas of common activity within or between organisations, where information and other resources are exchanged to guide an integrated viewpoint of strategy, business and technology [1]. It provides a blueprint for defining the structure and operation of organizations throughout these four layers, business, data, application and technology [2]. In brief, EA is a hierarchical way of describing how the information systems, business processes and people in an organization function as a whole [3-5].

EA will have high quality if it is understood, accepted, used and measured accordingly [6]. Measurement makes it possible to assess the EA value, efficiency and stakeholder satisfaction [7]. As stated by Bullen and Rockart [8], it is important to measure the performance status on a continual basis. However, there are three issues with the current EA assessment. Firstly, studies show only 16 EA assessment models exist [9, 10] and 63 per cent focus on post EA implementation [11]. Secondly, most of the existing EA assessment models are tied to a specific EA framework which means the solution cannot be generalized [12-14]. Finally, the existing EA assessment techniques are mostly based on checklist [15-17] or maturity model [18, 19]. The maturity model approach is best used if the organization has completed the EA implementation phase. However, it is not suitable to be used for pre and implementation phase because most of EA components are still at the development phase; hence, it is not possible to measure the actual EA progress. Meanwhile, manual checklist technique can be used to assess EA implementation, but it does not highlight activities priority. Therefore, inexperienced EA team member will execute EA implementation activities in sequence without realizing the activities can be optimized according to its importance.

This indicates that there is lack of systematic assessment mechanism, especially for pre and during EA implementation phase. Hence, based on the gap identified this study proposed to develop a priority based assessment model for pre and during the EA implementation process.

II. CURRENT WORKS ON EA IMPLEMENTATION ASSESSMENT

Generally, EA implementation (EAI) undergoes three phases: 1) the process of EA development and implementation, 2) the usage and operation of EA and 3) the maintenance of EA [20]. In this research context, phase 1 can be classified as pre and during EA implementation while phase 2 and 3 are post EA implementation. According to Schekkerman [21], for EA to be valuable to the organization, all three phases are equally important and need to be managed effectively. In order to recognize the quality and benefits of EA, various assessments are created either by academic researchers or the industry.

Findings from literature stated there are 16 EA assessment models since year 2001 until 2013 [11]. Figure 1 shows the growing number of models for over the last 10 years. As presented in Figure 2, 63 per cent of these models aimed for post EA implementation assessment, while the rest of 37 per cent were pre and during EA implementation assessment models. Five of these models were developed based on their own algorithm, three were created on Capability Maturity Model Integration (CMMI), two on Balanced Scorecard (BSC) and the rest were according to various theories as depicted in Table 1.

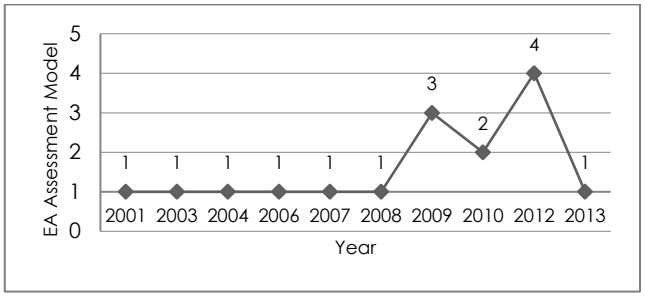

Figure 1: Number of EA assessment model by years

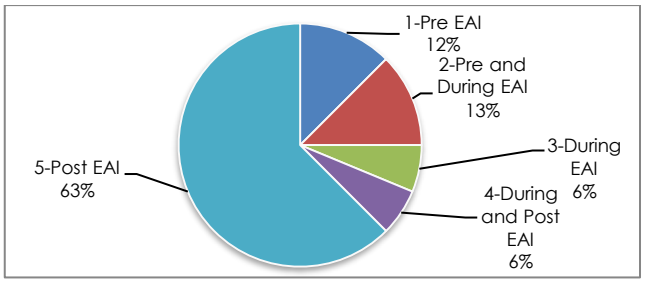

Figure 2: Percentage of EA assessment model by EAI phases

Table 1
Number of EA assessment model by fundamental theory

Fundamental Theory	Number of EA Assessment Model
Own algorithm	5
Capability Maturity Model Integration (CMMI)	3
Balanced Scorecard (BSC)	2
Control Objectives for Information and Related Technology (COBIT)	1
DeLone & McLean IS success model	1
Design Science Research (DSR)	1
Extended Enterprise Architecture Framework (E2AF)	1
Federated Enterprise Architecture (FEA)	1
Institutional theory	1
Total	16

From the analysis, it can be concluded most of the existing EA assessment models are available for post EA implementation. Only few models focused on pre and during EA implementation process and there has been a lack of systematic assessment techniques apart of the maturity model ranking. Realising this gap, a new systematic EA implementation assessment model has been proposed in this study.

III. Research Framework

To accomplish the research aim, this study proposed a new model known as Priority based EA Implementation Assessment Model (PEAIAM), which is the integration of Balanced Scorecard (BSC) by Kaplan and Norton [22] and Analytic Hierarchy Process (AHP) by Saaty [23].

A. *Balanced Scorecard (BSC)*

BSC is a strategic planning and management system that is widely applicable to organizations in any size or type of business. It consists of a set of measures to assess how the organization is progressing toward meeting its strategic goals. Originally, BSC consists of four perspectives, which are financial, customer, internal business process, and learning and growth perspective. For non-profit organization, Kaplan and Norton [24] introduced another measurement perspectives consisting of cost, authority support, internal process, and learning and growth perspective which are adapted in this study. To cater the prerequisites for the EA implementation, two perspectives, namely talent management and technology were added as enablers for the EA implementation.

B. *The Analytical Hierarchy Process (AHP)*

The AHP is a multi-criteria decision making (MCDM) method with the aim to model a complex problem in a hierarchical structure which consists of goal, objectives (criteria), sub objectives, and possible alternatives [23]. AHP integrates both criteria importance and alternative preference measures into a single overall score based on pairwise comparison judgments in order to rank decision alternatives. AHP does not prescribe correct decision, but it helps decision maker to find one that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem and quantifying its elements to overall goals and alternative solutions. AHP is widely applied to banking, oil and gas, manufacturing, landscape planning, medical, human resource management, quality management, rural management, defence, education and many more.

C. *Priority based EA Implementation Assessment Model (PEAIAM)*

Despite of its holistic measures, defining and maintaining a BSC can be very cumbersome and time consuming activity. This could result unnecessary diversion of resources and management time. Furthermore, this approach does not reflect the level of importance of the different metrics uses [25]. Hence, this study proposed an integration of AHP technique and BSC to produce more efficient and pragmatic EA implementation assessment model.

Based on six predefined BSC perspectives, systematic literatures review (SLR) and preliminary studies were conducted to identify the Critical Success Factors (CSFs) in EA implementation. Next, exploratory case studies were conducted at six organizations that have implemented the EA initiative with the aims to refine and revise the CSFs. All the CSFs were analysed via thematic analysis and coded accordingly. Finally, these assessment criteria were iteratively refined by EA experts until agreement was reached. As a result, six main criteria and 27 sub-criteria were identified as metrics in this assessment model. Figure 3 describes the main criteria and sub-criteria defined.

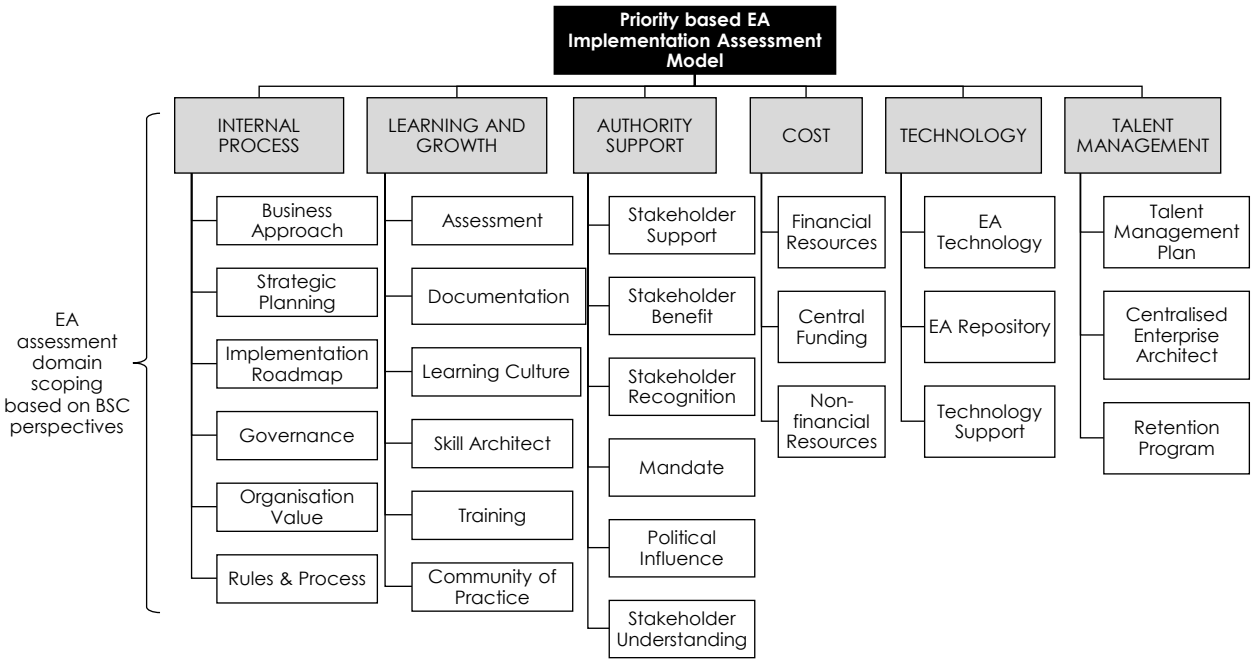

Figure 3: Domain scope and criteria defined for the proposed assessment model

IV. Discussion on Assessment Model Development Methodology

This section explains the methodology for assessment model development. The development process is presented in notation created on standard UML conventions proposed by van Steenbergen, Bos et al. [26]. There are four main steps in this methodology, which starts from scoping, design model, instrument development and finally implementation and improvement. Each step comprises detailed activities designated to the development of the model.

A. Step 1: Scoping

Activity 1: Identify and scope the domain. To ensure the right model is developed, it is important to scope the domain properly. For this model, the scope is on EA implementation assessment. It is also important to identify the other existing EA assessment models as it may be used as a basis for further enhancement and to avoid redundancy.

B. Step 2: Design model

Activity 2: Determine focus areas. The focus area is determined within the chosen domain, which in this case is EA implementation. Therefore for this model, the focus areas are based on six BSC perspectives, as explained in Section 3.3.

Activity 3: Determine assessment criteria. The next step is to determine the assessment criteria. In this model, these assessment criteria are derived from CSFs described in Section 3.3

Activity 4: Determine the metrics. Next, is to construct the metrics, which means identifying suitable measurement and analyze the suitable target that can be measured quantitatively. In this step, both BSC and AHP concept are applied. The metrics are derived from BSC perspectives and AHP calculation technique is appended to it. Therefore, all criteria are converted to be quantifiable metrics in order to perform the pairwise comparison analysis. The output of this step is n(n-1)/2 comparisons, where n is the number of elements.

C. Step 3: Develop instrument

Activity 5: Develop the decision matrix based on pairwise comparison. Upon design completion, the assessment instrument is constructed. The next four steps are fully dependent on AHP calculation. All pairwise comparison is arranged in a decision matrix. The weight is assigned through the questionnaires with the considerations that diagonal elements are equal or '1' and the other elements will simply be the reciprocals of the earlier comparisons. Pairwise comparisons are required in the scale of 1 to 9. 1 means equal importance, 3 for moderate importance, 5 for strong importance, 7 for very strong importance and 9 for extreme importance. The values of 2, 4, 6 and 8 are compromises between the previous definitions.

Activity 6: Calculate weight and prioritize each criterion. Next is the calculation of the weights assigned to the criterion. This involves the multiplication of the element priorities in a hierarchical level by the priorities of elements in the next higher level and adding them for each element in a level according to the attributes that it affects.

Activity 7: Calculate global weight of each criteria and final ranking. Next, after all lists of criteria are calculated, the global weight calculation is applied. This produces a composite or global priority of an element, which is used to weight the priorities of the elements in the level below, continuing recursively to the bottom level. As a final result, the design or weightage assign is based on overall consensus and not just based on one perspective or criteria only.

Activity 8: Calculate consistency index. The final calculation stage is to calculate a Consistency Ratio (CR). This is to measure the consistency of the judgments relative to large samples of purely random judgements. If the CR is much in excess of 0.1 the judgements are untrustworthy because they are too close for randomness and the assessment must be repeated. Therefore, to ensure its trustworthiness, Saaty [23] consequently suggested the use of a Consistency Ratio (CR) to check that pairwise input is transitive.

Activity 9: Develop assessment instrument. Finally, after all the calculation is completed and tested, the final assessment instrument is developed. This instrument consists

of both online and manual set of questionnaire designed earlier, according to BSC and AHP calculation.

D. Step 4: Implement and improvement

Activity 10: Implement EA assessment model. Implementation can be done in various ways. For this assessment model, the most suitable method is via a web based system. This is to ensure its accessibility and availability to all interested parties.

Activity 11: Improve EA assessment tool iteratively. Periodically this assessment tool will undergo the review process. To evaluate how the model and tool assists the EA implementation process, all assessment results are kept properly in a database and report will be generated for reference.

Activity 12: Communicate results. It is highly recommended to communicate the assessment results to EA practitioners and EA research community. This includes demonstration on real test case assessment results, publication of articles in scientific or professional journals and conference presentations.

Figure 4 summarizes the overall methodology of priority based the described EA implementation assessment model.

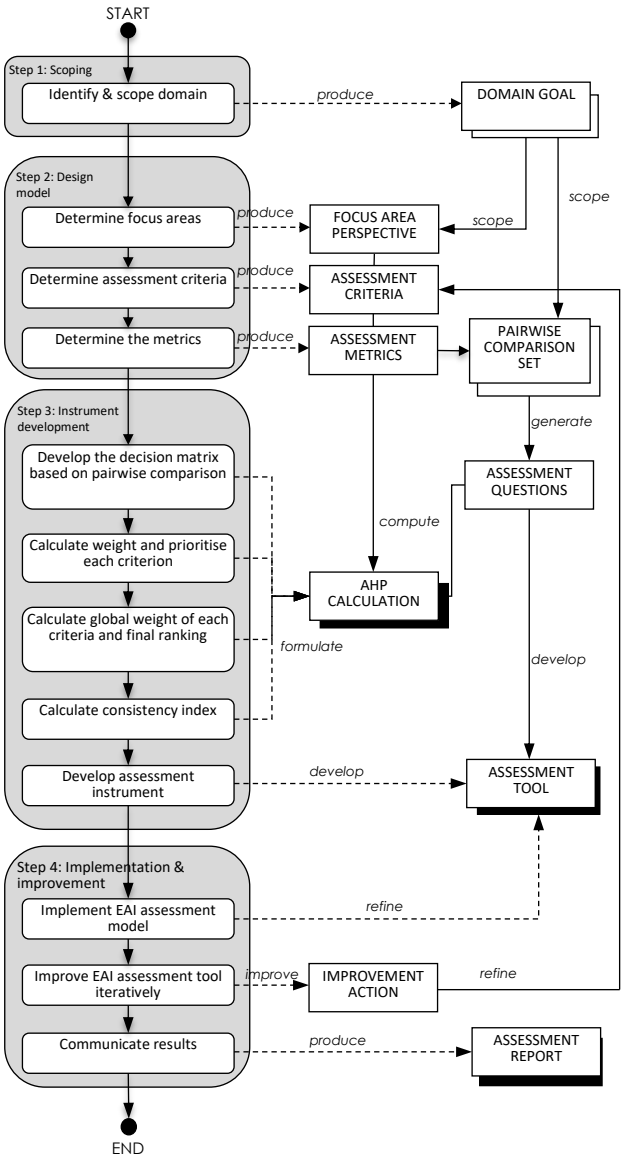

Figure 4: Assessment model development methodologies

V. Assessment Model Pilot Test Results

Upon completion of the assessment model development, a pilot study was conducted to ensure the model produced correct result and complied with AHP algorithm. For the testing purpose, the model was converted to a pairwise comparison tool in manual questionnaires form. A group of EA trained personnel in Malaysian Public Sector were asked to evaluate the criteria using the scale of 1 to 9 on each of 33 measurements (six main criteria and 27 sub-criteria) as per stated. The rating values were used to calculate the importance of EA implementation criteria consisting of overall score and individual score for each main criteria and sub-criteria defined.

All answers to each question were geometrically averaged before calculating the importance weights. The consistency test was performed to all the combined pairwise comparison matrixes. The results show that the Consistency Ratio (CR) values ranged from 0.0000 to 0.0628, which means that all the pairwise comparisons are consistent within the acceptable level recommended by Saaty [23]. This indicates that the participants have assigned their preferences consistently in determining the importance criteria in EA implementation.

Result shows that the importance main criteria for EA implementation was Cost with importance value 24.42%. This was followed by Authority Support (16.92%), Technology (16.50%), Internal Process (15.49%) and Learning and Growth (15.15%), in which the percentages were not much different from one another. The least important main criteria was Talent Management with 11.51%.

Within Cost criteria, the result shows Non-financial Resources was the most important criteria with the value of 47.44% compared to Central Funding (33.63%) and Financial Resources (18.94%). For Authority Support criteria, the most important sub-criteria was Stakeholder Understanding with 31.62% important value. The least importance sub-criteria in this group was Stakeholder Benefits which was only rated at 6.72%. In Technology group, the most important sub-criteria was EA technology, where the importance rate is at 69.33%. The rest of criteria, EA repository and technology support were only valued at 19.09% and 11.57% each.

For Learning and Growth aspect, 30.23% importance was on Community of Practice criteria. This was followed by training with 18.28% important rate. The rest of the criteria according to importance order were architect skill (15.56%), learning culture (14.26%), documentation (12.69%) and assessment (8.97%). The final aspect was talent management, whereby the pilot study shows talent management plan as the most important criteria (48.73%). The important of other criteria, Retention Program and Centralised Enterprise Architect were only rated at 28.04% and 23.24%.

The overall score and individual score of the main and sub-criteria are presented in Table 2.

VI. Conclusion

This paper described a method for developing a priority based EA implementation assessment model. From the extensive reviews on existing EA assessment model, we proposed a new assessment technique concentrating on pre and during in EA implementation process. The assessment criteria were derived and refined from various sources such

as literature reviews, preliminary study and exploratory case studies analysis. Guided on BSC perspectives, finally six main criteria and 27 sub-criteria were deployed in this model.

The pilot test conducted prove that priority based assessment approach is workable and able to produce a reliable results. In general, the participants agreed that this assessment tool is helpful and provides new insights for them in analysing the EA implementation criteria. Clear explanation prior to pilot test has eased the testing process, thus this has increased the quality of test results. As suggested by participants, this assessment model will be more practical if the result can be auto generated and available on web or mobile based application.

In summary, the proposed model aims to help the project team to assess their priority and capability in EA implementation process. The model can also be used with any of the existing EA framework and methodology available. The strength of this model is its ability to generate quantifiable analysis, thus contributed for objective results rather than subjective judgement used by the existing EA assessment models. By having this priority based assessment model, EA implementation team will be able to evaluate and monitor the progress to ensure the project is successfully delivered and in line with organization needs. In future, this priority based assessment model will be tested and evaluated by the EA experts and EA implementation team for its usability and reliability.

Table 2
The importance weights of EA implementation assessment measures

Main Criteria	Weight	Sub-Criteria	Weight
COST	0.2442	Non-financial Resources	0.4744
		Central Funding	0.3363
		Financial Resources	0.1894
AUTHORITY SUPPORT	0.1692	Stakeholder Understanding	0.3162
		Mandate	0.2310
		Stakeholder Recognition	0.1662
		Stakeholder Support	0.1163
		Political Influence	0.1032
		Stakeholder Benefit	0.0672
TECHNOLOGY	0.1650	EA Technology	0.6933
		EA Repository	0.1909
		Technology Support	0.1157
INTERNAL PROCESS	0.1549	Business Approach	0.2391
		Rules & Process	0.2211
		Implementation Roadmap	0.1514
		Organisation Value	0.1488
		Strategic Planning	0.1423
LEARNING AND GROWTH	0.1515	Governance	0.0973
		Community of Practice	0.3023
		Training	0.1828
		Skill Architect	0.1556
		Learning Culture	0.1426
		Documentation	0.1269
		Assessment	0.0897
TALENT MANAGEMENT	0.1151	Talent Management Plan	0.4873
		Retention Program	0.2804
		Centralised Enterprise Architect	0.2324

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