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Prioritizing Business Architecture Entities with Best-Worst Method

Mochammad Zuliansyah[1], Sabrina Ahmad[2] and Abdul Karim Mohamad[3]

[1]Lead Enterprise Architect, PT Epscilon SolusiIntegrasi, Jl. MT. HaryonoKav 17, Jakarta Selatan 12810, Indonesia.
[2]Associate Professor, CenterforAdvanced Computing Technology, Fakulti Teknologi Maklumat Dan Komunikasi, Universiti Teknikal Malaysia Melaka, Hang TuahJaya, DurianTunggal, Melaka, Malaysia.
[3]Senior Lecturer, Center for Advanced Computing Technology, Fakulti Teknologi Maklumat Dan Komunikasi, Universiti Teknikal Malaysia Melaka, Hang TuahJaya, DurianTunggal, Melaka, Malaysia.

(Corresponding author: Mochammad Zuliansyah)
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ABSTRACT: Enterprise Architecture (EA) is associated with alignment between business needs and IT services availability. Business architecture, as a part of EA, has a crucial role in understanding and blending with business needs. Through business architecture, the stakeholders' needs and interests are outline in detail. The level of data details in a business architecture can determine more support for strategic decision making in achieving business goals. Inaccurate determination of entity structure in business architecture affects the success rate of EA implementation. In an EA early implementation, an enterprise architect need to define an accurate entity structure. Unfortunately, current EA framework recommend generic entity structure. The challenge is how to define an accurate entity structure fo a particular industry. This study explores the determination of the core entities for business architecture that can guide the initiation of EA implementation. In this paper, an upstream petroleum industry sector is used as a case study. The selection of the core entities are done through two analysis stages. The first analysis is to determine the collection of business architecture entities from various EA standards, EA framework and EA guidance following the case study discussion. The second analysis refers to the steps of the Best-Worst Method (BWM) which provides comparative analysis. This study conducts two comparative analyses, and the first is the comparison of criteria which refers to the EA objective from the Federation of Enterprise Architecture Professional Organizations. The second comparison analysis is the comparison between entities of business architecture. The result of this study is to recommend the core components of business architecture entities which is part of the EA core content metamodel.A core business architecture entities consist of Business Capability, Risk, Finance, Value Stream, Compliance, Stakeholders, External Relationship, Project and Contract.

Keywords: Best-Worst Method, Business Architecture, Core Content Metamodel, Enterprise Architecture, Upstream Petroleum

Abbreviations: EA, enterprise architecture;BWM, Best-Worst Method; IT, information technology; PDA, portfolio decision analysis; TOGAF, the open group architecture framework; DoDAF, department of defense architecture framework; SME, small and medium-sized enterprises; FGD, focus group discussions; PCF, process classification framework; APQC, American productivity and quality center; PPDM, public petroleum data model association; MCDM, multi-criteria decision-making.

I. INTRODUCTION

The realization of business strategies in business architecture is the most challenging in Enterprise Architecture (EA) implementation. Strategic fit is the alignment between achieving business strategies and guarantees operational business processes that support organizational strategy. Business architecture is an architecture with various organizational perspectives that can provide a real understanding of the organization's business goals, governance of the implementation of each strategy, and supporting business decision making [20].

The study of business architecture based on business processes can affect the level of service decision making. Study in [22] examines the role of business architecture in supporting decision-making structure based on user interests. The role of business architecture is becoming increasingly important, considering that business architecture can support better decision making. Analysis of decision making indirectly impacts overall organizational performance.

Managing business processes as one of the elements in business architecture has the most challenges in accommodating dynamic business changes. A study [8] analyzes problems related to managing business processes flexibly. Alignment between formalization and standardization of business process modelling, and business operations that can change at any time, is an essential issue in the discussion of business architecture studies.

EA studies are often associated with the alignment between Information Technology (IT) services in supporting the business strategies achievement. The business architecture in EA is an architectural layer that plays an essential role in determining the relationship between IT and business. The business architecture approach, through the design of business processes, forms the basis of various decision support analysis. Optimization of business process implementation is closely related to the level of availability to support process resources. The resource allocation analysis discussed in [24] utilizing the portfolio decision analysis (PDA) method. Aligning the allocation of resources in the implementation of business processes is an effort in implementing IT governance.

The business architecture in EA is a combination of IT operational services and business activity modelling. Business architecture can direct business operations, establish integration between various systems, allocate IT resources and other supporting resources. A conceptual framework proposed in [1] was done by developing studies of business architecture through the achievement of business objectives based on strategic modelling, operational, and IT support—furthermore, the three models used as test parameters for the success rate of EA implementation. The strategy model consists of business intent, value proposition, and enterprise model, the operational model consists of business components, business processes, organization, and the IT model consists of IT architecture and IT operations.

The results of business architecture implementation evaluated by determining critical factors based on organizational characteristics. Critical factors in the business architecture implementation consist of adaptability, effectiveness, and efficiency [14]. The purpose of the business architecture is to provide an organizational blueprint that provides the same understanding to all stakeholders and aligned with the organization's strategic objectives and tactical needs.

The primary blueprint related to business needs consists of strategy maps, value streams, and capability maps [15]. Business mapping is used in business architecture to determine business strategy, value delivery, and operations aligned with specific business needs. Business needs are more directed to the statement of needs based on IT solutions. Requirements can be technical, business, functional, non-functional, high level or detail level requirements. Based on the methodology used by an organization, a holistic perspective of business needs tracing through a business architecture framework.

The implementation of business architecture influenced by the failure factors of EA implementation in various layers of architecture. Various factors can influence failure to implement EA. Causing factors include inconsistent leadership support [13], inaccurate anticipation in dealing with the impact of very rapid business changes [10], and metamodel formulations that are not following business needs [21].

This study explores entities in business architecture that support the initial phase of EA implementation. Data needs analysis in the business architecture entities refer to the needs of the upstream petroleum industry, and data gathering based on the preferences of four upstream petroleum companies in Indonesia.

Following Introduction, Section II discusses studies related to business architecture in various industrial sectors. Need to establish a metamodel as a basis for developing an EA repository is a crucial step. Section III discusses the methodology used in this study to determine the entities of simple business architecture. These entities are then classified to form the core content of business architecture metamodel. Section IV explains the results of the core entity study, which concluded in Section V. Section V also discussed the possibility of further research development.

II. RELATED WORKS

Studies on the business architecture domain have been settled out by various industrial sectors. The study of business architecture in the education sector discussed out in [3]. The study refers to the framework of The Open Group Architecture Framework (TOGAF) [9]. Business processes modelling and mapping with IT services become the basis of studies in forming a roadmap for the implementation of EA in a sustainable manner.

Implementation of business architecture in the military operational research sector resulted in an approach to determine components in business architecture based on the Department of Defense Architecture Framework (DoDAF) framework [5].

The study of business architecture in the healthcare sector [11] was developed to form an integrated model of the healthcare industry business. The study [11] produced business architecture modelling as a basis for developing business architecture models.

In the software development sector [15], the business architecture framework is utilized as a holistic reference point of view of the organization's overall business needs, the business architecture framework complemented by the interrelationship between business needs and various supporting resources.

In [23], a study conducted in determining the problems that limit organizations by carrying out process engineering. Utilization of business architecture based on sentimental analysis done to support small and medium industries in decision making. Studies with the sentimental analysis done based on market characteristics in the tourism sector.

Design and development of application prototypes done with a combination of business architecture capabilities and design models that support the analysis of the change impact. A study [6] proposed a metamodel and model based on a perspective of the business architecture capability—the model's design specifications based on business needs.

A study [4] recommends the structure of the EA metamodel that is built and evaluated in the SME operational process to support the implementation of EAs in small and medium-sized enterprises (SMEs). The proposed EA metamodel refers to the EA framework dimensions that are simple and easy to use. In general, the EA metamodel for SMEs consists of goals, actions, operations, and objects [4].

Implementing business architecture elements to support organizational strategies discuss in [2]. Strategies implementation increased with knowledge sharing between organizational members.

Another study [25] determines entities in the EA metamodel specifically in determining entities at the equivalent of general entities in the TOGAF core content metamodel. The selected general entities refer to the needs of the upstream petroleum industry.

Relationship between process-driven management as a part of business architecture and information system defined in digital transformation and enterprise architecture. In [16] discussed about the user role influence a information system development based on the principles of process-driven management.

III. METHODOLOGY

This study proposes business architecture entities that can support the EA core content metamodel development. Based on the purpose of the research, the following research questions are used as a basis for analysis:

Research Question 1 (RQ1): How to determine the source of reference in collecting business architecture entities?

Research Question 2 (RQ2): How to construct the mechanism to determine the priority of entities based on business preferences and needs?

To answer the two research questions, the steps taken in this study consist of:

— Screening is the process of selecting business architecture entities based on standards and references to answer RQ1,

— Selection is the process of analyzing the level of industry needs in business architecture entities that have selected in the first step. This step is to answer RQ2.

The need for business architecture in the upstream petroleum industry, affect a source of analytical data. Interviews and Focus Group Discussions (FGDs) conducted with stakeholders consisting of EA actors and implementers in four upstream petroleum companies in Indonesia.

A. Screening Stage

At this stage, searching and sorting standards, frameworks, and guidance related to the needs of business architecture in the upstream petroleum sector. Variety of business architecture entities obtained by referring to the standard reference, existing framework and guidance. The references used in this study consist of:

1. The Microsoft Upstream Reference Architecture [19],
2. Digital Transformation Initiative Oil and Gas Industry from the World Economic Forum [20],
3. Industry Reference Architecture: Business Capability Maps, Value Streams, and Strategy Maps for Upstream Oil & Gas [21],
4. The Petroleum Upstream Process Classification Framework (PCF) of the American Productivity and Quality Center (APQC) [22],
5. The Public Petroleum Data Model Association (PPDM) [23],
6. The Open Group Architecture Framework (TOGAF) [24].

From each of the references above, the business architecture entities were aggregated. The aggregation process concluded 23 potential entities to become core entities in the EA business architecture core metamodel. The list of entities:

1. Business Capability,
2. Project,
3. Stakeholders,
4. Risk,
5. Contract,
6. Finance,
7. Value Stream,
8. Compliance,
9. External relationship,
10. Operations,
11. Facility,
12. A course of Action,
13. Organization Unit,
14. Actor,
15. Function,
16. Role,
17. Process,
18. Wells,
19. Asset,
20. Asset Type,
21. Reservoir,
22. Service,
23. Security.

The list of entities above becomes the input in the next step and becomes the answer for RQ1. Priority level analysis is carried out based on the criteria on EA development objectives recommended by the Federation of Enterprise Architecture Professional Organizations [7, 12]. Entity priority criteria based on upstream petroleum industry preferences consist of effectiveness, efficiency, agility, and durability.

B. Selection Stage

Determination of priority levels for business architecture entities based on expert preferences from the upstream petroleum industry is done based on the Best-Worst Method (BWM) algorithm [17-19]. BWM is a Multi-Criteria Decision-Making (MCDM) method that analyzes priorities through two comparative steps. The first step is a comparison between the entity with the highest priority and the other entity (best criterion). The second step is comparing the entity with the lowest priority with the other entity (worst criterion). Based on the two comparison steps, two comparison vectors are formed. The result of BWM formulation is finding the optimal weight for each entity. Furthermore, a consistency ratio is tested at each comparison to ensure that the comparison made by experts carried out consistently.

IV. BWM STEPS

BWM consists of five steps below:

Step 1. Define the comparison criteria

In this first step, the comparison criteria determined to support decision making (Cr_1, Cr_2, ..., Cr_n). This list of criteria used as a perspective in determining the weight of each entity.

Step 2. Define the best and worst criteria

The best criteria are the criteria that are most needed, most important, or most dominant than the other criteria. The selection of the best criteria is made as a comparison of each criterion incrementally towards the best criteria. The worst criterion is the most neglected, least important, least influential criterion for choosing a business architecture entity. The selection of the worst criteria as a decremental comparison for each criterion compared with the priority level of the worst criterion.

Step 3. Define the best criteria preference compared to other criteria

This step is comparing the best criteria with other criteria based on a Likert scale. This comparison using the scale number between 1 and 9. The lowest value of 1 represents a comparison between criteria having the same priority level. The highest value, 9, represents a comparison between criteria that one criterion is most important than another criterion. The results of this comparison produce a Best-to-Others (BO) vector formulated as follows:

$$A_B = (a_{B1}, a_{B2}, \ldots, a_{Bn}) \quad (1)$$

Where a_{Bj} define the best criteria *B*, compared to a particular criterion *j*.

Step 4. Define the other criteria preference compared to the worst criterion

This step compares each other criteria with the worst criteria. Comparisons are made based on a Likert scale with quantification of numbers between 1 and 9. The lowest value of 1 represents a comparison between criteria that have the same low priority level. The highest value, 9, represents a comparison between criteria that a criterion has a much lower priority than other criteria. The results of this comparison produce an Others-to-Worst (OW) vector formulated as follows:

$$A_W = \left(a_{1W}, a_{2W}, \ldots, a_{nW}\right)^T \quad (2)$$

a_{jW} defines the criterion with *j* preference which compared to the worst criterion *W*.

Step 5. Define the entities optimal weight

This step determines the optimal weight of each criterion by referring to the absolute maximum difference $\{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\}$ for all minimum values *j*. Then it can be formulated as follows [18]:

$$\min \max_j \{|w_b - a_{Bj}w_j|, |w_j - a_{jW}w_W|\} \quad (3)$$

s.t.

$$\sum_j w_j = 1$$

$$w_j \geq 0, for all j$$

The formulation above can be written back in the linear programming formulation as follows:

$$\min \xi^L \quad (4)$$

s.t.

$$|w_B - a_{Bj}w_j| \leq \xi^L, for all j$$

$$|w_j - a_{jW}w_W| \leq \xi^L, for all j$$

$$\sum_j w_j = 1$$

$$w_j \geq 0, for all j$$

Equation (4) is a linear problem and has a unique answer. This equation produces an optimal weight (w^*_1, w^*_2, ..., w^*) and an optimal value of ξ^L expressed as ξ^{L^*}. The consistency ratio ξ^{L^*} is the level of consistency of comparison between criteria. If the value of the consistency ratio is close to zero, then the preference of experts in making comparisons between criteria is more consistent. Thus, for the value of the higher consistency ratio, indicating the preference of experts on the comparison between criteria is not consistent. If the experts' preferences are not consistent, it is recommended to conduct an interview or re-focus group discussion.

BWM formulation can produce optimal weights from each criterion expressed as w_j^*. BWM is also used to calculate the weight of each criterion with various alternative entities xijk. This weight can then normalize as x_{ijk}^{norm}. The final value for each alternative entity k is stated in Vik and can be calculated based on the following equation:

$$V_{ik} = \sum_{j=1}^{n} w_j x_{ijk}^{norm} \quad (5)$$

$$x_{ijk}^{norm} = \begin{cases} \frac{x_{ijk}}{max\{x_{ijk}\}} \\ 1 - \frac{x_{ijk}}{max\{x_{ijk}\}} \end{cases} \quad (6)$$

V. CRITERIA WEIGHTING

The determination of the weight of business architecture criteria refers to the preferences of the speakers by referring to the EA development objectives of the Federation of Enterprise Architecture Professional Organizations. Weight comparison between criteria done through comparative analysis based on BWM. Furthermore, the determination of criteria weights in business architecture refers to the results of interviews and FGDs with EA actors and stakeholders from four upstream petroleum companies in Indonesia. The results of the data gathering used as input to the BWM methodology. This comparative analysis carried out to answer RQ2.

Step 1. Define the comparison criteria

Based on the screening stage in the methodology section, the criteria to be used as a basis for comparison of business architecture entities consist of:

1. Effectiveness (Cr_1),
2. Efficiency (Cr_2),
3. Agility (Cr_3), and
4. Durability (Cr_4).

The comparison process in the following steps uses these four criteria as a reference and comparison perspective.

Step 2. Define the best and worst criteria

This step determines the best criteria and the worst criteria based on the justification of the experts and practitioners representing the interests of four Indonesian upstream petroleum companies. The four companies stated as E1, E2, E3, dan E4. Justification results illustrated as the following Table 1:

Table 1: Best and Worst Criteria.

Criterion	Company Preferences	
	Best Criteria	Worst Criteria
Effectiveness	E_1, E_2	
Efficiency	E_3, E_4	
Agility		E_3, E_4
Durability		E_1, E_2

Based on the preferences of the four upstream petroleum companies above, a preference pattern founded. E_1 and E_2 companies have an equal preference for best and worst criteria. Whereas companies E_3 and E_4 have equal preferences but differ from E_1 and E_2. The uniformity of these preferences caused by various reasons. But in general, this uniform preference might be influenced by company classification. E_1 and E_2 are both large companies, while E_3 and E_4 are medium-sized companies. The similarity of preferences between large and medium-sized companies requires further study to prove that the uniformity of preference patterns is consistent or not. But the discussion of the similarity of preferences is not included in the scope of this study.

Step 3. Define the best criteria preference compared to other criteria

In this step, a comparison made between the best criteria and other criteria. Quantification of comparison values refers to the results of interviews and FGDs with experts. The recapitulation of the Best-to-Others (BO) comparison results illustrated in Table 2.

The lowest value of 1 indicated if a comparison between criteria having the same priority level. The highest value, 9, indicated if a comparison between criteria that one criterion is more important than another criterion. Based on Table 2, it concludes that the Effectiveness criteria is the most dominant criterion, which rated as the best criterion. The Effectiveness Criteria are the best for E_1 and E_2, and the second-best for E_3 and E_4.

Step 4. Define the other criteria preference compared to the worst criterion

This step compares each other criteria with the worst criteria. Quantification of comparison values refers to the results of interviews and FGDs with experts. A summary of the results of the Others-to-Worst (OW) comparison illustrated in Table 3.

The lowest value of 1 indicates a comparison between criteria that has the same low priority level. The highest value, 9, indicates a comparison between criteria that a criterion has a much lower priority than other criteria. Based on Table 3 it concluded that the Durability criterion is the most dominant as the worst criterion. Durability criteria are the worst for E_1 and E_2, and the second-worst for E_3 and E_4.

Step 5. Define the criteria optimal weight

This step determines the optimal weight of each criterion by referring to the BWM linear model formulation as written in equation 3. Weights are justified by the experts, then averaged to get a single weight vector as written in Table 4.

ξ^{L*} states the consistency ratio of the expert's preferences in determining the value of comparisons between criteria. In Table 4, the value ξ^{L*} close to zero value. A value of ξ^{L*} close to zero indicates that comparisons made by experts have made consistently. The weighted average results state that the effectiveness criterion is the most critical in developing business architecture in the upstream petroleum sector. The next order of critical criterion level is efficiency, agility, and durability. However, the weight deviation between effectiveness and efficiency is less than 0.1. The same pattern occurs between the criteria of agility and durability. This pattern suggests that the use of effectiveness criteria as a goal for developing business architecture has the potential to be juxtaposed with efficiency goals.

Table 2: Best-to-Others (BO) vector.

BEST-TO-OTHERS					
Criterion	**Best**	Effectiveness	Effectiveness	Efficiency	Efficiency
	Companies	E_1	E_2	E_3	E_4
	C1:Effectiveness	1	1	2	2
	C2:Efficiency	5	3	1	1
	C3:Agility	3	6	9	9
	C4:Durability	9	9	7	7

Table 3: Others-to-Worst (OW) vector.

OTHERS-TO-WORST					
Criterion	**Worst**	Durability	Durability	Agility	Agility
	Companies	E_1	E_2	E_3	E_4
	C1:Effectiveness	9	9	8	8
	C2:Efficiency	3	6	9	9
	C3:Agility	5	3	1	1
	C4:Durability	1	1	3	3

Table 4: Consistency Ratio for Criteria Weights.

	Weights	**Companies**				**Mean**
		E_1	**E_2**	**E_3**	**E_4**	
Criteria	C1:Effectiveness	0.5903	0.5967	0.3159	0.3159	0.4547
	C2:Efficiency	0.1319	0.2320	0.5433	0.5433	0.3627
	C3:Agility	0.2199	0.1160	0.0505	0.0505	0.1093
	C4:Durability	0.0579	0.0552	0.0903	0.0903	0.0734
	a_{BW}	9,0000	9,0000	9,0000	9,0000	
	CI	4.4700	5.2300	5.2300	5.2300	
	ξ^*	0.0694	0.0994	0.0884	0.0884	
	ξ^{L*}	**0.0155**	**0.0190**	**0.0169**	**0.0169**	

VI. ENTITY PRIORITIZATION

After obtaining the weight of each criterion, the next step is to determine the priority of each business architecture entity. Entity priority is the multiplication of expert preferences with the weight of each criterion. Referring to the data gathering on weighting criteria, weight comparisons between entities done with interviews and FGDs with the experts and practitioners representing the interests of four Indonesian upstream petroleum companies. Weight comparison refers to a nine-point Likert scale. A value of 1 means very important, and a value of 9 means very unimportant. In the entity comparison process, business architecture entities grouped into three component groups, namely:

1. Organization Component consists of:
   a. Finance,
   b. Risk,
   c. Compliance,
   d. Business Capability,
   e. Value Stream,
   f. A course of Action,
   g. Service,
   h. Security,
2. People component consists of:
   i. Stakeholders,
   j. Organization Unit,
   k. Actor,
   l. Function,
   m. Role,
   n. Process,
   o. External relationship,
3. Petroleum Component consists of:
   p. Reservoir,
   q. Contract,
   r. Project,
   s. Operations,
   t. Wells,
   u. Facility,
   v. Asset,
   w. Asset Type.

The results of data collection based on interviews and FGDs recapitulated in Table 5.

The consistency ratiowas conductedto justify the expert consistency for each comparison. Following the business architecture entity grouping, the consistency ratio performed for each entity group is based on the BWM linear model formulation. Table 6 represents the calculation results of the consistency ratio for the Organization Component group.

In Table 6, value ξ^{L^*} is close to zero. It indicates that comparisons made by experts on the organization component are carried out consistently. Next, Table 7 represents the results of the calculation of the consistency ratio for the People Component group.

In Table 7, valueξ^{L^*} is close to zero. It indicates that comparisons made by experts on the people component are carried out consistently. Next table 8 represents the results of the calculation of the consistency ratio for the Petroleum Component group.

In Table 8, value ξ^{L^*} is close to zero. It indicates that the comparisons made by experts on petroleum components are carried out consistently. In addition to calculating the consistency ratio at each entity per group, it is also necessary to test the consistency ratio between groups—the results of the consistency ratio test per group illustrated in Table 9.

In Table 9, value ξ^{L^*} is close to zero. It indicates that comparisons between groups of entities by experts are carried out consistently. The average weight values for the organization, people, and petroleum components show the dominance of organization components. This comparison shows that the role of entities related to the organization has a dominant role in shaping business architecture metamodel in the upstream petroleum sector.

Then the weights of each entity are done by averaging the weights per entity for all criteria. The results are then normalized by using equation 6. The final weight of each entity is a cumulative result between each criterion weight and per each criterion weight, as illustrated in Table 10.

Ordering the weight of entities based on the final score produces a sequence of recommendations for the use of entities as a business architecture core metamodel. This recommendation refers to expert justification in the upstream petroleum industry. The recommended order of entities in each group illustrated in Table 11. Based on the weight data in Table 11, the average weight calculated in the organizational component is 0.3855, people component 0.3274, and in the petroleum component 0.3127. Entities in the organization component with weights above its average value consist of Business Capability, Risk, Finance, Value Stream, and Compliance. People component entities with weights above its average values consist of Stakeholders, and External Relationships. Entities in the petroleum component with above its average weights consist of Project and Contract. These results are RQ2 answers and entities with more than average weights recommended to be part of the core entities of business architecture metamodel.

Table 5: Business Architecture entity comparison.

		Effectiveness				Efficiency				Agility				Durability			
	Entitities	E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4	E_1	E_2	E_3	E_4
Org. Component	Finance	1	5	4	8	1	4	4	7	2	1	4	6	1	1	3	5
	Risk	2	8	3	3	5	8	3	1	1	8	2	1	3	8	4	3
	Compliance	2	6	6	3	5	5	7	1	1	6	7	1	3	7	6	3
	Bus Capa	2	3	2	3	5	2	2	1	4	5	3	1	2	3	2	3
	Val Stream	2	9	2	3	5	9	2	1	4	9	3	1	2	9	2	3
	Courseof Act	4	9	2	9	2	9	2	8	3	9	3	9	6	9	2	9
	Service	8	9	8	8	3	9	6	7	8	9	5	6	4	9	7	5
	Security	9	9	9	4	8	9	9	6	9	9	9	5	9	9	9	6
le Com	Stakeholders	2	4	1	2	5	6	1	3	4	7	1	4	2	6	1	2
	Org Unit	6	9	7	1	4	9	8	2	6	9	8	3	7	9	8	1

	Actor	6	9	7	1	4	9	8	2	6	9	8	3	7	9	8	1
	Function	6	9	7	1	4	9	8	2	6	9	8	3	7	9	8	1
	Role	6	9	7	1	4	9	8	2	6	9	8	3	7	9	8	1
	Process	6	7	8	8	4	7	6	7	6	4	5	6	7	4	7	5
	ExtRelationship	9	9	1	2	8	9	1	3	9	9	1	4	9	9	1	2
Petroleum Comp.	Reservoir	3	9	5	7	7	9	5	9	8	9	6	8	5	9	5	8
	Contract	4	2	3	8	2	3	3	7	3	3	2	6	6	5	3	5
	Project	4	1	3	5	2	1	3	4	3	2	2	2	6	2	4	4
	Operations	5	9	5	5	2	9	5	4	5	9	6	2	8	9	5	4
	Wells	5	9	5	7	2	9	5	9	5	9	6	8	8	9	5	8
	Facility	5	9	5	5	2	9	5	4	5	9	6	2	8	9	5	4
	Asset	7	9	5	6	6	9	5	5	7	9	6	7	5	9	5	7
	Asset Type	7	9	5	6	6	9	5	5	7	9	6	7	5	9	5	7

Table 6: Consistency Ratio for Organization Component.

	Weights	**Companies**				**Mean**
		E_1	**E_2**	**E_3**	**E_4**	
Organization Component	Finance	0.3329	0.2074	0.0810	0.0519	0.1683
	Risk	0.2026	0.1037	0.1013	0.1037	0.1278
	Compliance	0.1351	0.1383	0.0675	0.1383	0.1198
	Business Capability	0.1013	0.3407	0.3329	0.3407	0.2789
	Value Stream	0.0810	0.0691	0.2026	0.2074	0.1400
	Course of Action	0.0675	0.0593	0.1351	0.0296	0.0729
	Service	0.0507	0.0519	0.0507	0.0593	0.0531
	Security	0.0289	0.0296	0.0289	0.0691	0.0392
	a_{BW}	9.0000	9.0000	9.0000	9.0000	
	CI	5.2300	5.2300	5.2300	5.2300	
	ξ^*	0.0724	0.0741	0.0724	0.0741	
	ξ^{L*}	**0.0138**	**0.0142**	**0.0138**	**0.0142**	

Table 7: Consistency Ratio for People Component.

	Weights	Companies				Mean
		E_1	**E_2**	**E_3**	**E_4**	
People Component	Stakeholders	0.4077	0.4077	0.3829	0.0845	0.3207
	Organization Unit	0.2451	0.0980	0.1149	0.3521	0.2025
	Actor	0.0980	0.0817	0.0919	0.2113	0.1207
	Function	0.0817	0.0700	0.0766	0.1056	0.0835
	Role	0.0700	0.0613	0.0656	0.1408	0.0845
	Process	0.0613	0.2451	0.0383	0.0352	0.0950
	External Relationship	0.0361	0.0361	0.2298	0.0704	0.0931
	a_{BW}	9.0000	9.0000	9.0000	8.0000	
	CI	5.2300	5.2300	5.2300	4.4700	
	ξ^*	0.0826	0.0826	0.0766	0.0704	
	ξ^{L*}	**0.0158**	**0.0158**	**0.0146**	**0.0158**	

Table 8: Consistency Ratio for Petroleum Component.

	Weights	**Companies**				**Mean**
		E_1	**E_2**	**E_3**	**E_4**	
Petroleum Component	Reservoir	0.3329	0.0627	0.0627	0.0604	0.1297
	Contract	0.2026	0.2196	0.3607	0.0306	0.2034
	Project	0.1351	0.3607	0.2196	0.1409	0.2140
	Operations	0.1013	0.0732	0.0549	0.3491	0.1446
	Wells	0.0810	0.0549	0.0732	0.0528	0.0655
	Facility	0.0675	0.0314	0.0314	0.2113	0.0854
	Asset	0.0507	0.1098	0.1098	0.0845	0.0887
	Asset Type	0.0289	0.0878	0.0878	0.0704	0.0688
	a_{BW}	9.0000	9.0000	9.0000	9.0000	
	CI	5.2300	5.2300	5.2300	5.2300	
	ξ^*	0.0724	0.0784	0.0784	0.0735	
	ξ^{L*}	**0.0138**	**0.0150**	**0.0150**	**0.0141**	

Table 9: Consistency Ratio between Components.

Weights	Companies				Mean
	E_1	E_2	E_3	E_4	
Org	0,6444	0,5625	0,3125	0,0909	0,4026
People	0,1111	0,1250	0,5625	0,6727	0,3678
Petroleum	0,2444	0,3125	0,1250	0,2364	0,2296
a_{BW}	5,0000	4,0000	4,0000	7,0000	
CI	2,3000	1,6300	1,6300	3,7300	
ξ*	0,0889	0,0625	0,0625	0,0364	
CR	**0,0386**	**0,0383**	**0,0383**	**0,0097**	

Table 10: Normalized entities weight.

	Entitities	Effectiveness		Efficiency		Agility		Durability		Weights
		Mean	Norm	Mean	Norm	Mean	Norm	Mean	Norm	
Organization Component	Finance	4,5000	0,4545	4,0000	0,5000	3,2500	0,5938	0,6970	0,5040	0,5040
	Risk	4,0000	0,5152	4,2500	0,4688	3,0000	0,6250	0,4545	0,5059	0,5059
	Compliance	4,2500	0,4848	4,5000	0,4375	3,7500	0,5313	0,4242	0,4683	0,4683
	Business Capability	2,5000	0,6970	2,5000	0,6875	3,2500	0,5938	0,6970	0,6823	0,6823
	Value Stream	4,0000	0,5152	4,2500	0,4688	4,2500	0,4688	0,5152	0,4933	0,4933
	Course of Action	6,0000	0,2727	5,2500	0,3438	6,0000	0,2500	0,2121	0,2916	0,2916
	Service	8,2500	0,0000	6,2500	0,2188	7,0000	0,1250	0,2424	0,1108	0,1108
	Security	7,7500	0,0606	8,0000	0,0000	8,0000	0,0000	0,0000	0,0276	0,0276
People Component	Stakeholders	2,2500	0,7273	3,7500	0,5313	4,0000	0,5000	0,6667	0,6269	0,6269
	Organization Unit	5,7500	0,3030	5,7500	0,2813	6,5000	0,1875	0,2424	0,2781	0,2781
	Actor	5,7500	0,3030	5,7500	0,2813	6,5000	0,1875	0,2424	0,2781	0,2781
	Function	5,7500	0,3030	5,7500	0,2813	6,5000	0,1875	0,2424	0,2781	0,2781
	Role	5,7500	0,3030	5,7500	0,2813	6,5000	0,1875	0,2424	0,2781	0,2781
	Process	7,2500	0,1212	6,0000	0,2500	5,2500	0,3438	0,3030	0,2056	0,2056
	External Relationship	5,2500	0,3636	5,2500	0,3438	5,7500	0,2813	0,3636	0,3474	0,3474
Petroleum Component	Reservoir	6,0000	0,2727	7,5000	0,0625	7,7500	0,0313	0,1818	0,1634	0,1634
	Contract	4,2500	0,4848	3,7500	0,5313	3,5000	0,5625	0,4242	0,5057	0,5057
	Project	3,2500	0,6061	2,5000	0,6875	2,2500	0,7188	0,5152	0,6412	0,6412
	Operations	6,0000	0,2727	5,0000	0,3750	5,5000	0,3125	0,2121	0,3097	0,3097
	Wells	6,5000	0,2121	6,2500	0,2188	7,0000	0,1250	0,0909	0,1961	0,1961
	Facility	6,0000	0,2727	5,0000	0,3750	5,5000	0,3125	0,2121	0,3097	0,3097
	Asset	6,7500	0,1818	6,2500	0,2188	7,2500	0,0938	0,2121	0,1878	0,1878
	Asset Type	6,7500	0,1818	6,2500	0,2188	7,2500	0,0938	0,2121	0,1878	0,1878

Table 11: Final entities scores.

	No.	Entitities	Weights
Organization Component	1	Business Capability	0,6823
	2	Risk	0,5059
	3	Finance	0,5040
	4	Value Stream	0,4933
	5	Compliance	0,4683
	6	Course of Action	0,2916
	7	Service	0,1108
	8	Security	0,0276
	No.	**Entitities**	**Weights**
People Component	1	Stakeholders	0,6269
	2	External Relationship	0,3474
	3	Organization Unit	0,2781
	4	Actor	0,2781
	5	Function	0,2781
	6	Role	0,2781
	7	Process	0,2056
	No.	**Entitities**	**Weights**
Petroleum Component	1	Project	0,6412
	2	Contract	0,5057
	3	Operations	0,3097
	4	Facility	0,3097
	5	Wells	0,1961
	6	Asset	0,1878
	7	Asset Type	0,1878
	8	Reservoir	0,1634

VII. CONCLUSION

This research contributesto recommend the core entities of business architecture metamodel. These entities are essential elements at the beginning of EA development, especially in the upstream petroleum sector. Two analyses were carried out to answer the research questions. The first analysis is an analysis to gather a list of entities in the business architecture that refers to standards, frameworks, and EA development guidance. In the first analysis, twenty-three entities and four criteria consisting of effectiveness, efficiency, agility, and durability had founded.

The second analysis refers to the stages of the Best-Worst Method (BWM) and the comparative analysis was carried out twice. The first analyses was to compare the level of priority between criterias. The second analyses was to compare the priority levels between business architecture entities. A comparative analysis conducted referring to the justification of experts who are stakeholders implementing EA in four upstream petroleum companies in Indonesia. To maintain the quality of expert justification, a consistency ratio test is performed for both, criteria comparison and between entities comparison. Criteria comparison result for first company is 0.0155, second company is 0.0190, third company is 0.0169, and forth company is 0.069. Entities comparison construct from each criterion shows for first company is 0.0386, second company is 0.0383, third company is 0.0383, and forth company is 0.0097. The competency ratio test found that the justification of the experts shows an indication of consistency. These results act as a basis of the data collection validity.

Based on two comparison analysis results, it is prioritized the entities as the core content metamodel of business architecture. The contribution of this paper is a recommended core business architecture entities consist of Business Capability, Risk, Finance, Value Stream, Compliance, Stakeholders, External Relationship, Project and Contract.

VIII. FUTURE SCOPE

In future, the method in this study can be used as a reference in determining EA entities at the initiation of EA implementation in various industrial sectors. Besides, the evaluation mechanism for the success of EA implementation has become a challenge for many parties. This challenge can be an opportunity for further development and research.

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REFERENCES

[1]. Al-Malaise AL-Ghamdi, A. S. (2017). A proposed model to measure the impact of business architecture. Cogent *Business and Management, 4*(1), 1–8. https://doi.org/10.1080/23311975.2017.1405493

[2]. Al-Mansour, J., & Al-Nesafi, A. (2019). Influence of shared knowledge in accounting departments when implementing organizational strategies: Kuwait as a case study. *International Journal on Emerging Technologies, 10(*4), 222–232.

[3]. Anggara Wijaya, I. N. Y., & Setyohadi, D. B. (2017). Analysis business architecture study case: Medical colleges in purwokerto. *Advanced Science Letters, 23*(3), 2401–2403. https://doi.org/10.1166/asl.2017.8648

[4]. Bernaert, M., Poels, G., Snoeck, M., & De Backer, M. (2016). CHOOSE: Towards a metamodel for enterprise architecture in small and medium-sized enterprises. *Information Systems Frontiers, 18*(4), 781–818. https://doi.org/10.1007/s10796-015-9559-0

[5]. Department of Defense Deputy Chief Information Officer. (2011). The DoDAF Architecture Framework Version 2 . 02. *DoDAF Journal*.

[6]. Du Toit, F. A., & Tanner, M. (2015). A business architecture capability meta model and tool-set for providing function point estimation for enterprise architecture management. *Lecture Notes in Engineering and Computer Science, 1*, 482–494.

[7]. Federation of Enterprise Architecture Professional Organizations. (2013). A Common Perspective on Enterprise Architecture. Architecture and Governance Magazine, 9, 6. https://doi.org/10.4018/978-1-60566-659-664

[8]. Gromoff, A., Bilinkis, Y., & Kazantsev, N. (2017). Business Architecture Flexibility as a Result of Knowledge-Intensive Process Management. *Global Journal of Flexible Systems Management, 18(*1), 73–86. https://doi.org/10.1007/s40171-016-0150-4

[9]. Group, T. O. (2013i). TOGAF® Version 9.1.

[10]. Kappelman, L., Mclean, E., Vess, J., & Gerhart, N. (2014). The 2014 SIM IT Key Issues and Trends Study. MIS Quarterly Executive, 237–263.

[11]. Nugraha, D. C. A., Aknuranda, I., Andarini, S., & Roebijoso, J. (2017). A business architecture modeling methodology to support the integration of primary health care: Implementation of primary health care in Indonesia. *Internetworking Indonesia Journal*, *9*(1), 39–45.

[12]. Paradkar, S. (2016). Cracking the IT Architect Interview. Packt Publishing.

[13]. Porter, M. E. (2008). the Five Forces That Competitive Strategy. *Harvard Business Review, 86*, 78–94. https://doi.org/Article

[14]. Puerta-Ramírez, J. E., Giraldo-García, J. A., & Tabares-López, M. L. (2019). Evaluación de la Arquitectura de Negocio a través del Análisis de Factores Críticos para el Desempeño de una Organización. *Información Tecnológica, 30*(2), 33–44. https://doi.org/10.4067/s0718-07642019000200033

[15]. Randell, A. A., Spellman, E., Ulrich, W., Wallk, J., Clark, R. M., Elliott, E., & Melaragno, W. (2014). Leveraging Business Architecture to Improve Business Requirements Analysis.

[16]. Řepa, V. (2020). Business Process-Based IS Development as a Natural Way to Human-Centered Digital Enterprise Architecture. International KES Conference on Human Centred Intelligent Systems; Split; Croatia, 359–368. https://doi.org/10.1007/978-981-15-5784-2_29

[17]. Rezaei, J. (2015). Author ' s Accepted Manuscript Best-worst multi-criteria decision-making method : Some properties and a linear model. Omega. https://doi.org/10.1016/j.omega.2015.12.001
[18]. Rezaei, J. (2015). Best-worst multi-criteria decision-making method. Omega (United Kingdom), 53, 49–57. https://doi.org/10.1016/j.omega.2014.11.009
[19]. Rezaei, J., Nispeling, T., Sarkis, J., & Tavasszy, L. (2016). A supplier selection life cycle approach integrating traditional and environmental criteria using the best worst method. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2016.06.125
[20]. Roelens, B., Steenacker, W., & Poels, G. (2017). Realizing strategic fit within the business architecture: the design of a Process-Goal Alignment modeling and analysis technique*. Software and Systems Modeling*, 1–32. https://doi.org/10.1007/s10270-016-0574-5
[21]. Roeleven, S. (2010). Why Two Thirds of Enterprise Architecture Projects Fail An explanation for the limited success of architecture projects.
[22]. Seltani, R., Aknin, N., Amjad, S., & El Kadiri, K. E. (2016). Process-oriented business architecture for a conscious decision making based on users' interests. *Journal of Theoretical and Applied Information Technology, 94*(1), 151–158.
[23]. Zapata, G., Murga, J., Raymundo, C., Dominguez, F., Moguerza, J. M., & Alvarez, J. M. (2019). Business information architecture for successful project implementation based on sentiment analysis in the tourist sector. *Journal of Intelligent Information Systems, 53*(3), 563–585. https://doi.org/10.1007/s10844-019-00564-x
[24]. Zhang, M., Chen, H., & Liu, J. (2019). Resource allocation approach to associate business-IT alignment to enterprise architecture design. *Journal of Systems Engineering and Electronics, 30*(2), 343–351. https://doi.org/10.21629/JSEE.2019.02.13
[25]. Zuliansyah, M., Desa, M. I., & Ahmad, S. (2019). Selecting general entities for TOGAF's core content metamodel using best worst method. *International Journal of Innovative Technology and Exploring Engineering, 9*(1), 3857–3863. https://doi.org/10.35940/ijitee.A4938.119119

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