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Designing enterprise architecture based on TOGAF 9.1 framework

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Abstract— The development and utilization of information technology in everyday life continues to grow rapidly within the passage of time. As a result, organizations or companies have many choices in determining the information technology to be applied in their organizations or companies. To ensure that information technology solutions implemented by enterprises are able to help companies properly solve their problems, the solution must take into consideration the culture and condition of the enterprises and the capabilities of information technology held at that time. The solution should also be able to integrate the company's data and systems, take advantage of existing enterprises capabilities, and ensure that the enterprises' resources are ready to transform from the current state to the target state. Based on the requirements statement, the right information technology solution to be applied to enterprises is enterprise architecture. From the existing enterprise architecture frameworks, TOGAF framework is chosen as the framework that will be used in this paper by reason of the completeness of the process, integrated processes, and flexibility. Expected results from the design of enterprise architecture in this paper is the target of enterprise architecture to be achieved, gap analysis between the initial architecture and targets, as well as project roadmap to assist enterprises in achieving the desired target and solve their current problems. In this paper, the design of enterprise architecture by applying TOGAF framework will be done on one of state-owned enterprises (BUMN) in Indonesia.

1. Introduction

The development and utilization of information technology in everyday life continues to grow rapidly within the passage of time. As a result, organizations or companies have many choices in determining the information technology to be applied in their organizations or companies. For state-owned enterprises, the information technology solutions implemented should not only in accordance with the needs of the enterprise but also comply with the government's rules and regulations. The chosen solutions need to pay attention to the culture and condition of the organization and the capabilities of information technology owned at the time, as well as able to integrate the data and system of the enterprise. This is because state-owned enterprises tend to have fragmented data and system spread across different branches which can cause several issues such as missing data or system not being able to be implemented across all branches. Enterprises should also ensure that the resources they currently owned is ready to evolve from the current conditions to the expected conditions. On that basis, the right information technology solution to be applied to state-owned enterprises is the enterprise architecture.

Enterprise architecture is a technology and management practice aimed at developing enterprise performance by helping them see themselves in the context of a holistic and integrated view of their technology resources, information flow, business practices, and strategic direction [1]. Enterprise architecture aims to optimize enterprise's fragmented

business processes into an integrated and responsive environment towards changes as well as able to support the delivery of business strategies [2]. There are currently many enterprise architecture frameworks that can be used by organizations or companies, but based on Cameron & McMillan's research on the five most commonly used enterprise architecture frameworks, TOGAF frameworks are rated as far superior compared to other frameworks. The advantages of TOGAF include process completion, TOGAF ADM, flexibility in the use of elements, integration / interconnection between layers, vendor neutrality, and alignment with industry standards [3].

The focus of this paper is designing enterprise architecture on multi-branch state-owned enterprise with different business units using the TOGAF 9.1 framework approach, which includes the use of TOGAF ADM (Architecture Development Model), to integrate currently existing and implemented data and systems in the enterprise.

2. Theoretical Basis

2.1. Enterprise Architecture

Enterprise architecture is a technology and management practice aimed at developing enterprise performance by helping them see themselves in the context of a holistic and integrated view of their technology resources, their information flow, business practices, and strategic direction [1]. The key to enterprise architecture is the iterative process, which includes the process of creating, managing, and, ultimately, utilizing enterprise architecture [4]. Enterprise architecture also analyzes the gap between target state and current state, and provides a road map that supports the enterprise's transformation toward the target state to complete and close the existing gap [5].

The purpose of enterprise architecture is to optimize enterprise's business processes that tend to be fragmented into an integrated and responsive environment towards changes as well as able to support the delivery of business strategies. The benefits of implementing enterprise architecture are as follows [2]:

- More efficient business process
- More efficient information technology process
- Increase in return on investment (ROI) and decrease in investment risk
- Faster, simpler, and cheaper procurement

2.2. Enterprise Architecture Framework

There are currently many enterprise architecture frameworks that can be used by organizations or companies according to their needs. The four most widely used frameworks in the industry today are Zachman Framework, Gartner Framework, Federal Enterprise Architecture (FEA), and The Open Group Architecture Framework (TOGAF) [4]. However, based on the results of research conducted by Cameron & McMillan on some of the most commonly used enterprise architecture frameworks, TOGAF framework is considered as far superior compared to other frameworks. The results of this comparison can be seen in Table 1[5].

Table 1. Comparison of Enterprise Architecture Framework

Attributes/Criterias	Zachman	TOGAF	DoDAF	FEA	Gartner
Business alignment with information technology / business focus	1	3	1	1	4
Taxonomy guide	4	2	2	3	1
Reference model	1	3	2	4	1
Completeness of process	1	4	1	2	3
Rating of maturity	1	2	2	3	3
Governance support	1	2	3	3	3
Interoperability / flexibility	2	4	3	3	2
Knowledge repository / information availability	2	4	2	2	1
Standards (architecture, industry, government)	2	4	3	3	1
Best of breed / Best fit	2	4	2	3	1
Integration / Connectivity between layers	3	4	2	3	2
Business alignment with information technology / business focus	2	4	2	3	1

The advantages of TOGAF include process completion, TOGAF ADM, flexibility in the use of elements, integration / interconnection between layers, vendor neutrality, and alignment with industry standards. Based on these reasons, the enterprise architecture framework to be used in this research is TOGAF framework. The core of TOGAF itself is the TOGAF ADM (Architecture Development Method), where TOGAF ADM presents iterative and tested processes to develop the architecture. The processes are divided into different sections and phases as shown in Figure 1.
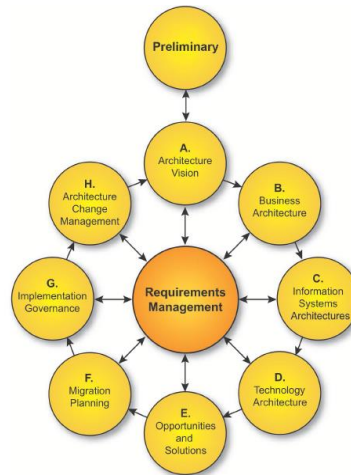

Figure 1. TOGAF ADM's Iterations and Phases

Here are the sections and phases in TOGAF ADM [2].
- Architecture Context
  - Preliminary Phase
  - Phase A: Architecture Vision
- Architecture Development
  - Phase B: Business Architecture
  - Phase C: Information Systems Architecture
  - Phase D: Technology Architecture
- Transition Plan
  - Phase E: Opportunities and Solutions
  - Phase F: Migration Planning
- Architecture Governance
  - Phase G: Implementation Governance
  - Phase H: Architecture Change Management
- Requirements Management

2.3. Related Researches
The explanation of several studies that have been conducted related to the company architecture and its application can be seen in Table 2.

Table 2. Related Researches

Research Title	Author(s)	Research Focus	Lack in Research
Approach in Designing Effective Enterprise Architecture [6]	Glissmann & Sanz, 2011	Propose approach to make effective enterprise architecture. The approach discussed in this study can be combined with other	It has never been tested in real situations where existing enterprise architecturestandards (such as TOGAF or Zachman) have been tailored to the specifications of the companies concerned

		enterprise architecture standards	
Designing Enterprise Architecture to Ensure Business and IT Strategic Alignment (SAMM Integration with TOGAF 9.1) [7]	Novianto Budi Kurniawan; Suhardi, 2013	Providing solutions for designing enterprise architectures that can provide assurance for business and IT strategic alignment designed through the integration of SAM components with TOGAF 9.1 metamodel	The results are still too generic and testing is not carried out through clear case studies, more about the selection and explanation of each artifact
Enterprise Architecture for Development of Cloud-Based ERP System [8]	Ardian Indra Gunawan, 2014	Application and use of enterprise architecture to manage enterprise IT resources with a major focus on cloud-based ERP adaptation and development with multi-tennant concepts	Evaluation of the application of enterprise architecture implemented without clear or previously-defined samples and references
Designing Enterprise Architecture for Application of Integrated Information System at Multi-Branches Organization [9]	Dilla Anindita, 2016	Designing an enterprise architecture model suitable for multi-branches organizations that can be used to integrate information systems within the organization	The scope of research does not arrive at the implementation stage of enterprise architecture, only to the D (Technology Architecture) phase of the TOGAF 9.1 framework. In addition, no research has been done to verify whether the developed enterprise architecture method can be used for other enterprise scopes other than multi-branches hospitals
Analysis on Recent Trends Related to Enterprise Architecture Frameworks [3]	Hilman Ramadhan, 2016	Studies related to enterprise architecture frameworks that are most often applied to organizations as well as what attributes are required of an organization to ensure that the enterprise architecture designed meet their needs	The scope of the study does not extend to the framework-making stage or methodology that can assist the organization in defining criteria and guidelines for creating and utilizing the hybrid framework of enterprise architecture

3. Analysis of Design Method

3.1. Enterprise Architecture Requirements Analysis
To ensure that the enterprise architecture designed can help enterprises meet their strategic needs and objectives, the enterprise architecture requirements need to be determined. These requirements will be used as references while designing the enterprise architecture. With reference to the definition of enterprise architecture described in the Theoretical Basis section, the enterprise architecture requirements for the targeted enterprise are as follows.

- *Define the enterprise's IT and IS capabilities* [1] [2]
- *Ensure all branch offices have implemented standards and use predefined applications* [1] [2] [5]
- *Integrate the enterprise's data and systems as a whole* [1]
- *Carry out readiness assessment regarding the application of enterprise architecture for the enterprise* [5]
- *Determine the best approach to develop the architecture while considering the current and target conditions* [1] [2]
- *Minimize current constraints* [1] [2]
- *Minimize the infrastructure gap between branch offices* [1] [2]
- *Develop project roadmap to support the company's transformation to meet the target enterprise architecture* [5]

3.2. Determine the Scope of the Enterprise Architecture Framework
As described in sub-chapter 2.2, the design of the enterprise architecture model for the targeted enterprise will utilize the TOGAF 9.1 framework. The method adopted from TOGAF 9.1 and used in the design of enterprise architecture model for this paper is the TOGAF ADM method. While taking the role and needs of enterprise architecture described in sub-chapter 3.1 into account, the scope of TOGAF ADM framework can be determined starting from Preliminary Phase, followed by Phase A: Architecture Vision, Phase B: Business Architecture, Phase C: Information Systems Architecture, and Phase D: Technology Architecture.

3.3. Enterprise Architecture Design Method
Once the scope of the enterprise architecture framework to be used is determined, the next step is to describe the steps of the design method itself. The goal is to make sure that the scope and focus of the development of enterprise architecture has a clear focus and deliverables that are also in accordance with the needs of the company. The steps of the enterprise architecture design method established for this paper can be seen in the diagram in Figure 2.
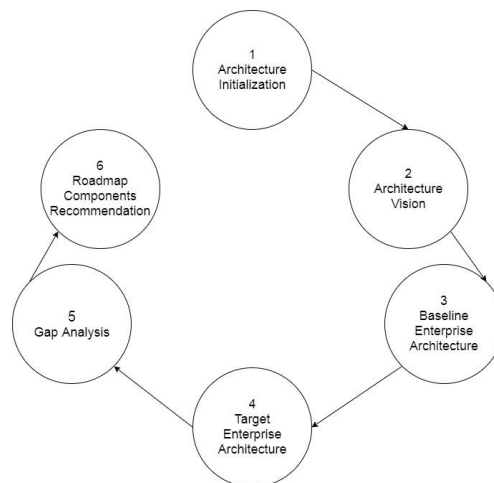

Figure 2. Enterprise Architecture Design Method

The explanation of the enterprise architecture design method is as follows.
- Architecture Initialization
  The focus of this phase is to define the current state of the enterprise and the principles of enterprise architecture implementation for the enterprise. This phase refers to the Preliminary Phase of TOGAF ADM. Activities undertaken in this phase include identifying organization profile; identifying organization scope, capabilities, and constraints; identifying architecture principles; and identifying business goals and business drivers.
- Architecture Vision
  The focus of this phase is to define the purpose of implementing enterprise architecture for the enterprise and to assess the company's readiness in transforming to achieve the target enterprise architecture. This phase refers to Phase A: Architecture Vision of TOGAF ADM. Activities undertaken in this phase include identifying of architecture vision; assessing current business capabilities; and business transformation readiness assessment.
- Baseline Enterprise Architecture
  The focus of this phase is to define the current state of business, information systems, and technology architecture of the enterprise. This phase refers to Phase B: Business Architecture, Phase C: Information Systems Architecture, and Phase D: Technology Architecture of TOGAF ADM. Activities undertaken in this phase include defining the baseline business architecture; defining the baseline data architecture; defining the baseline application architecture; and defining the baseline technology architecture.

- Target Enterprise Architecture
  The focus of this phase is to define the target state of business, information systems, and technology architecture of the enterprise. This phase refers to Phase B: Business Architecture, Phase C: Information Systems Architecture, and Phase D: Technology Architecture of TOGAF ADM. Activities undertaken in this phase include defining the target business architecture; defining the target data architecture; defining the target application architecture; and defining the target technology architecture.
- Gap Analysis
  The focus of this phase is to analyze the gaps on each architecture layers. This phase refers to Phase B: Business Architecture, Phase C: Information Systems Architecture, and Phase D: Technology Architecture of TOGAF ADM. Activities undertaken in this phase include analyzing gaps between baseline and target business architectures; analyzing gaps between baseline and target data architectures; analyzing gaps between baseline and target application architectures; and analyzing gaps between baseline and target technology architectures.
- Roadmap Components Recommendation
  The focus of this phase is to determine the roadmap components for the development of enterprise architecture based on the gap analysis results. This phase refers to Phase B: Business Architecture, Phase C: Information Systems Architecture, and Phase D: Technology Architecture of TOGAF ADM. Activities undertaken in this phase include determining the projects to be undertaken during the development of enterprise architecture; creating a priority order for the projects; and creating a migration plan.

4. Enterprise Architecture Design Results

4.1. Enterprise Architecture Principles
Based on the TOGAF 9.1 framework, the definition of architecture principles is a set of principles related to architectural work [2]. Architecture principles manage the architecture process, impacting the development, management, and use of enterprise architecture. The architectural principles will be discussed in accordance with the four domains of enterprise architecture, namely business principles, data, applications, and technology. Detailed principles can be seen in Table 3.

Table 3. Enterprise Architecture Principles

Principle Category	Principle Name
Business Principle	Business continuity
	Compliance with the law
	Provide benefits to the company
	IT responsibilities
Data Principle	Data is an asset
	Integrated data between branches
	Data is accessible
	Data security
Application Principle	Application is reliable
	Application is cost-effective
	Application is reliable
Technology Principle	Interoperability
	Responsive change management

4.2. Architecture Vision
The architecture vision can be determined based on the current state of the company as well as the company's mission, business objectives, business drivers, and business constraints. Figure 3 explains the origin of the architectural vision more clearly.
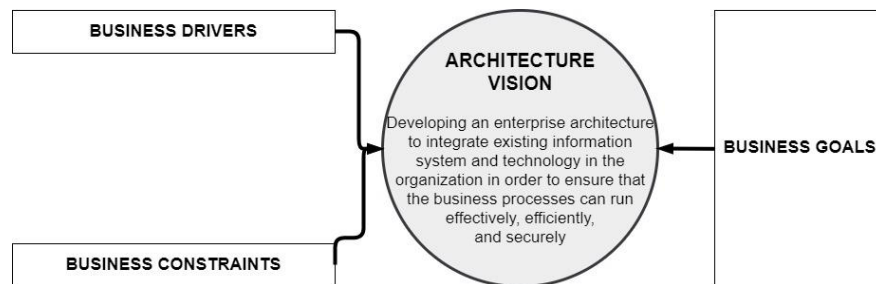
Figure 3. Architecture Vision

4.3. Results of Business Transformation Readiness Assessment
One of the keys to successful architecture transformation is to understand the enterprise's readiness to accept changes, identify issues at hand, and solve them. The goal of the assessment is to evaluate the conformity of the enterprise architecture that has been developed. This activity is called Business Transformation Readiness Assessment. The method suggested by the TOGAF 9.1 framework to assess the organization's readiness is the Business Transformation Enablement Program (BTEP) in accordance with Phase A: Architecture Vision of TOGAF ADM [2].

Readiness factors for the readiness assessment are determined based in the BTEP method. Readiness factors along with the results of the assessment conducted on the targeted enterprise can be viewed in Table 4.

Table 4. Business Transformation Readiness Assessment

Factor	Assessment	Description
Vision	Good	The enterprise has a clear architecture development vision which is in accordance with the needs and capabilities of the enterprise
Desire, Willingness, and Resolve	Good	The enterprise has a strong desire and commitment in executing and completing the enterprise architecture development project and is ready to face the impact of the project development
Need	Good	The enterprise has clear reasons and needs related to the enterprise architecture development project
Business Case	Good	The enterprise architecture development project for the enterprise is supported by the problems, needs, and business opportunities that is currently faced by the enterprise
Funding	Good	The enterprise has a clear source of funding to meet the expenditure and procurement of the enterprise architecture development project
Sponsorship and Leadership	Enough	The enterprise's executives provide the support needed for the project
Governance	Enough	The enterprise involves interested parties to the project with the purpose of ensuring that the company's interests and its objectives are met
Accountability	Enough	The presence of assigned specific and appropriate responsibilities to human resources that have an appropriate role to develop, execute, and implement the results of enterprise architecture development projects across branches
Workable Approach and Execution Model	Bad	The enterprise has a reference in project modeling and uses a reasonable and relative approach for the task
IT Capacity to Execute	Enough	The enterprise have IT resources and can run IT processes smoothly
Enterprise Capacity to Execute	Enough	The enterprise have resources outside of the IT area to do all the work required during the project

Enterprise Ability to Implement and Operate	Enough	The enterprise may accept and adjust the changes that occur as a result of project implementation

Based on the assessment results, the targeted enterprise is considered quite ready in carrying out business transformation.

4.4. Target Enterprise Architecture
The discussion regarding target enterprise architecture can be reviewed by understanding the description of target business, information systems, and target architectures as the realization of the architecture vision

- *Target Business Architecture*
  The realization of architecture vision in the context of business architecture is implemented through improving the effectiveness and efficiency of business processes, the adjustment of business actors and their roles, and the addition of business activities related to decision making on existing business processes and functions. Issues that exist in the baseline business architecture of the targeted enterprise will be solved in the target business architecture. The issue and its solutions are as follows:
  - Data issues that have not been well validated in the baseline business architecture will be solved by the addition of specific business functionality to evaluate data in the target business architecture
  - The issue of the absence of business processes to support the socialization of services provided by the targeted enterprise in the baseline business architecture will be solved by the addition of a marketing division in the target business architecture
  - The issue of the absence of formal-defined activities to manage the organization's data center in the baseline business architecture will be solved with the addition of specific business functionality to maintain in the target business architecture
- *Target Data Architecture*
  Target data architecture can be mapped by understanding the target picture of the data architecture and the target relationship between data architecture and business architecture. Issues that exist in the baseline data architecture of the targeted enterprise will be solved in the target data architecture. The issue and its solutions are as follows:
  - The issue of the absence of specific data entities related to data center maintenance in the baseline data architecture will be solved by the addition of related data entities in the target data architecture
  - The issue of the absence of specific data entities to support the socialization of services in the baseline data architecture will be solved by the addition of related data entities in the target data architecture
- *Target Application Architecture*
  Target application architecture can be mapped by understanding the target application structure and how target applications are connected to each other. Issues that exist in the baseline application architecture of the enterprise will be solved in the target application architecture. The issue and its solutions are as follows:
  - The issue of lack of applications to support business processes in the baseline application architecture will be solved by adding several business applications to support the organization's business processes in the target application architecture
  - The issue that not all applications are integrated in the baseline application architecture will be solved by integrating all business applications so that they can be centrally accessed in the target application architecture
- *Target Technology Architecture*
  Issues that exist in the baseline technology architecture of the targeted enterprise are mostly related to the quality of existing information technology infrastructure as well as the security of information systems. Based on these findings, the target technology architecture for the destination organization has several focuses:
  - Evaluate the quality of information technology infrastructure so as to improve the quality of infrastructure owned by the organization
  - Develop backup system for the enterprise's information system as a whole, unlike current backup system which only focused on some parts of the system

    o Improve data center maintenance and governance through the addition of formal-defined business functions related to the data center

4.5. Gap Analysis

Gap analysis between the baseline and target enterprise architectures is done on each architecture layers to ensure that all components are properly mapped. The results of gap analysis that is done on the targeted enterprise can be seen on Table 5. The results of this analysis will be used as a reference in determining the projects for migration plan and project roadmap.

Table 5. Results of Gap Analysis

Gap Title	Related Architecture Layer
Addition of Data Evaluation business functions	Business, Technology
Addition of Data Center Maintenance business function	Business, Data, Technology
Addition of Marketing division	Business Data
Development of business applications	Application
Integration of business applications	Application
Evaluate the security quality of information technology infrastructure	Technology
Development of backup system for whole information system	Technology

4.6 Projects Recommendation as Roadmap Components

Roadmap components for the targeted enterprise are determined based on the main gaps. The results of mapping the main gaps into roadmap components can be seen in Table 6.

Table 6. Mapping Gaps to Projects

Project Title	Related Gap
Business Application Development Project	Development of business applications
Business Application Integration Project	Integration of business applications
Marketing Division Realization Project	Addition of Marketing division
Business Function of Data Center Maintenance Realization Project	Addition of Data Center Maintenance business function
Business Function of Data Evaluation Realization Project	Addition of Data Evaluation business functions
Information Technology Infrastructures Quality Evaluation Project	Evaluate the security quality of information technology infrastructure
Backup System Development for Overall Information System Project	Development of backup system for whole information system

4.7. Migration Plan

Preferred projects are then sorted based on their priorities before being mapped into the roadmap components. The priority mapping can be carried out by taking into account of several factors such as the results of previous business transformation readiness assessment and the dependencies between each project. The list of projects to be worked one based on their priorities can be seen in Table 7.

Table 7. Priority of Projects to be Worked on

Project Title	Priority
Business Application Development Project	High
Business Application Integration Project	High
Marketing Division Realization Project	Medium
Business Function of Data Center Maintenance Realization Project	Medium
Business Function of Data Evaluation Realization Project	High
Information Technology Infrastructures Quality Evaluation Project	Medium
Backup System Development for Overall Information System Project	Medium

Based on the result of priority determination, the sequence of the proposed project work in sequence is as follows

- Business Application Development Project
- Business Application Integration Project
- Business Function of Data Evaluation Realization Project
- Business Function of Data Center Maintenance Realization Project
- Backup System Development for Overall Information System Project
- Information Technology Infrastructures Quality Evaluation Project
- Marketing Division Realization Project

After determining these priorities, a migration plan detailing the implementation of each project including the year of which the implementation will take place. The migration plan of the objective organization in this study can be seen in Figure 4.
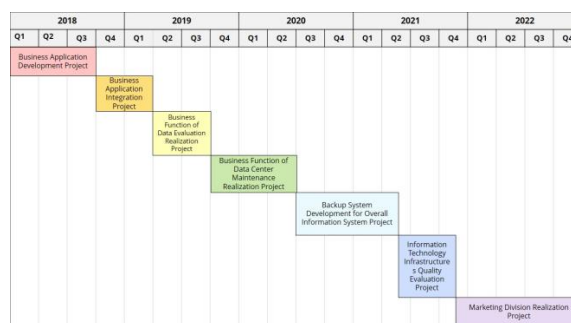

Figure 4. Migration Plan for the Targeted Enterprise

5. Conclusions

In designing and developing enterprise architecture that suits the needs of the state-ownedenterprise, there are several things to be considered including the business objectives, business drivers, business constraints of the company. In addition, the enterprise should also take into account the scope of the enterprise architecture design itself as well as the scope of application of the enterprise architecture framework to be used. Key components required in designing enterprise architecture for enterprises are the components of the four major domains of architecture, ie business, data, application, and technology, with a primary focus on,

- Defining and mapping the enterprise's capabilities,
- Integrating data and system as a whole,
- Assessing the company's readiness to transform, and
- Planning the transition

The application of enterprise architecture will affect the enterprise's business processes, especially in realizing the company's values in the form of well-functioned business processes and functions, data quality improvement, realization of integrated information systems, and evaluation and improvement of information technology infrastructure.

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