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].

| Attributes/Criteria                              | 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](image)

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.

| 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 architectures | It has never been tested in real situations where existing enterprise architecture standards (such as TOGAF or Zachman) have been tailored to the specifications of the companies concerned |
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.

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.

| 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.
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.

| 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      | Good       | The enterprise has a strong desire and commitment in executing and completing the enterprise architecture development project and ready to face the impact of the project development |
| Resolve                       |            |                                                                                                                                          |
| 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         | Bad        | The enterprise has a reference in project modeling and uses a reasonable and relative approach for the task                                 |
| Execution Model               |            |                                                                                                                                          |
| 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                                         |

Figure 3. Architecture Vision
| 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
- 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.

| 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.

| 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.

| 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.

![Migration Plan for the Targeted Enterprise](image)

**Figure 4. Migration Plan for the Targeted Enterprise**

5. Conclusions

In designing and developing enterprise architecture that suits the needs of the state-owned enterprise, 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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