Enterprise Architecture Planning for Enterprise University Information System Using the TOGAF Architecture Development Method

U Ulmi*, A P G Putra1, Y D P Ginting3, I L Laily4, F Humani5, Y Ruldeviyani6
Faculty of Computer Science, Universitas Indonesia, Indonesia

Email: *ulfah.ulmi@ui.ac.id

Abstract. One of the important strategies in dealing with the development of information technology is the usage and increase of information systems support for the enterprise. Enterprise University Information System (EUIS), a product released by the University of Indonesia Computer Science Center, is a cloud-based system that can help the academic community-run main and supporting processes with data that can be tracked in real-time. EUIS is currently used by several clients. In the future, the company is targeting technological developments in EUIS that can be used by many other universities, so it can be easily adjusted and integrated with existing information systems at the client. Therefore, an update of enterprise architecture is needed to support the alignment of IT with existing business needs. The enterprise architecture design method used in Enterprise Architecture Planning (EAP) with the Open Group Architecture Framework (TOGAF). In this research using a qualitative methodology, TOGAF ADM can assist in planning architectural changes from monolithic to micro services by identifying several scenarios. The results showed that the decentralized microservice architecture design can be applied to EUIS. Pusilkom UI currently has implemented this design with a client that has condition 2, so that further research can be tested for other conditions.

1. Introduction
Information technology is currently developing rapidly that it has a big impact on companies in running business processes and determining speed in decision making. Under these circumstances make information technology one of the main resources in a company or organization to improve performance in achieving company goals. One important strategy in dealing with the development of information technology is the use and increase of information systems support for the enterprise [1].

University of Indonesia Computer Science Center or commonly called Pusilkom UI has been established since 1972. Pusilkom UI has a lot to do in developing the world of information technology, both in academia and industry/business. In its business, Pusilkom has a product in the form of an Enterprise University Information System (EUIS). EUIS is a cloud-based system that can help the academic community-run main and supporting processes with data that can be tracked in real-time [2]. EUIS is currently used by several educational institutions, but in the future, the company is targeting to develop technology in EUIS that can be used by many other institutions.

At present, the system architecture in EUIS is still centralized, that thus affecting the performance of the EUIS system and has a more complex level of difficulty for adding and developing functions to the system. In the future, with the increasing number of EUIS users and additional functions needed, a
system that can support every business need in general or specifically exists in each institution. Therefore it is needed an update of the enterprise architecture that can support the alignment of IT with existing business needs, namely business needs that can make an institution's data can be integrated with products also offered by Pusilkom UI [2].

Enterprise Architecture (EA) is defined as a representation of the structure and behavior of a company's business processes [3]. There are various types of paradigms and methods that can be used in designing enterprise architecture, including the Zachman Framework, TOGAF-ADM, EAP, and others. In designing enterprise architecture in this study using TOGAF-ADM, which aims to get a clear picture of how to design an enterprise architecture as well as how to get a good enterprise architecture and can be used by companies to achieve their goals [4].

Research related to enterprise architecture has been conducted on information systems at Semarang State University. Research using the Zachman framework [3]. In the Strategic Information System Planning research using TOGAF ADM at Galuh Ciamis University by making a proposed architecture as a guide for companies to manage their information systems, especially in the proposed technology architecture to help in integrating information systems and data from all activities in Galuh Ciamis University [5]. Both studies only focus on the conditions that exist in each university.

This research aims to design an enterprise architecture using the TOGAF framework, which is a case study at EUIS which is a university information system that is general for various educational institutions in general. The concept of microservice and Software as a Service (SaaS) is used in EUIS to support the use of a variety of other institutions. This research seeks to obtain the right enterprise architecture design in the EUIS system to meet business needs. The output that can be achieved from the enterprise architecture design is to produce a model and basic framework (blueprint) in developing information systems to support the needs of the UI Pusilkom Company.

2. Literature Review

2.1. Enterprise architecture (EA)

Architecture in an information system is a field of science that focuses on the construction of structural foundations, behavioral characteristics, and guiding principles, changes and operations in the manufacture and development of systems in the long run [6]. Departing from this understanding, Enterprise Architecture (EA) is defined as a representation of the structure and behavior of a company's business processes.

EA describes the existing system and the system in the future. EA includes several things, including a) Insights into the use of the latest information technology in the company's business operations, b) Shadow for the future use of information technology in business operations, c) Roadmap for the evolution of the information technology landscape from current to future circumstances along with the temporary state of them [6]. From the standpoint of business processes and IT infrastructure, Ross, Weill, and Robertson define EA as an organizing logic that reflects the requirements for integration and standardization of the company's operating model [7]. The method for building an EA uses Enterprise Architecture Planning which will be explained in the next point.

2.2. Enterprise architecture planning (EAP)

Enterprise Architecture Planning (EAP) is a method used to develop EA. EAP is also an approach to planning the quality of data from manufacturing information systems. EAP covers the structure and strategy of data and information, business systems, and technology architecture. In EAP, several architectures are defined, namely: Data Architecture, Application Architecture and Technology Architecture [8].

This method consists of four levels/stages, namely [8]:

- Level 1: Planning Initiation
- Level 2: Business Modeling - Current System and Technology
- Level 3: Data Architecture - Application Architecture - Technology Architecture
- Level 4: Implementation / Migration Plan
2.3. The Open Group Architecture Framework - Architecture Development Method (TOGAF-ADM)

TOGAF-ADM is a framework for EAP. Architecture Development Method (ADM) is a method that contains activities used in modeling and development in corporate architecture. ADM can be categorized as a corporate architecture process, not an architectural framework or methodology.

TOGAF defines basic knowledge in architecture, among others: Technical Reference Model (TRM) and Standards Information Base (SIB). TRM is used for IT architecture in general, while SIB is a collection of standards considered in building IT architecture [9].

An organization that builds company architecture will usually be assisted by ADM. TOGAF-ADM consists of eight phases shown in Figure 1. Implementation of corporate architecture in some organizations may experience difficulties, especially for organizations that do not have trust between the business side and the technical side of the organization. This difficulty causes the company to decide to use an external consultant in implementing the company's architecture [9].

In Figure 1, the architecture of vision created in circle A will be the main input into circle B. The TOGAF consultants in circle B aim to make a breakdown of the basic objectives and targets of the business architecture and conduct a gap analysis. Circle C applies to information systems architecture as was done in Circle B. Circle D discusses technology architecture to complement the technical architecture and information technology infrastructure needed. The technology architecture considers various implementation possibilities, identifies implementation projects that must be carried out and evaluates related business opportunities [9]. This stage is the earliest phase of a data architecture design.

![Figure 1. TOGAF Architecture Development Method (ADM)](image)

2.4. Software as a Service (SaaS)

The development of EUIS as a SaaS which has a multi-tenant target will be done with the microservices architecture. Software as a Service (SaaS) is a software delivery model that allows customers to change and limit the software they use. For SaaS targeted at multi-tenants, it has a high complexity [10].

To achieve economies of scale, SaaS must be configurable, cover multi-tenants efficiently, and scalable. The approach that can be used to fulfill SaaS requirements with economies of scale is to use the microservices architecture. Microservices Architecture is an architectural style with a focus on
small services (microservices), decentralized, and autonomous. This collection of services will work
together and form a single piece of software [8].

3. Research Method
This research used descriptive method by analyzing the need for enhancement of the EUIS SaaS at
PUSILKOM UI, which is the Academic System for Universities, especially in the design of data
architecture. The analysis activity is carried out through primary data obtained from interviews with
the leaders of the relevant developers, and secondary data obtained from document studies.

Primary data is data originating from the first party or source. This data is not available in the
compiled form or the form of files. This data must be obtained through interviewees or technical terms
of the respondent, namely people who can be used as research objects or people who are used as a
means to obtain information or data [11], while secondary data is data that is available so that we only
need to find and collect data [11].

Based on the primary data obtained, PUSILKOM UI wants to do a EUIS SaaS enhancement for the
academic system for universities, wherein its implementation of a micro service concept is needed so
that accessing data on EUIS has good performance. Based on secondary data, we obtained the existing
EUIS data structure. The location of the research conducted is at PUSILKOM UI.

In creating a framework for producing output following the objectives of the study, a conceptual
model was designed. The resulting conceptual model is divided into two levels. The first level is a
model to describe what factors are involved in the data architecture design process so that it can
describe the final goal of designing a data architecture contained in the information architecture
domain. The second level is a model to describe the technical details of what factors are involved in
the process of designing the data architecture for the EUIS SaaS to accommodate the needs of the
university. Figure 2 is a EUIS conceptual model for Level 1 and in Figure 3 is a conceptual model of
EUIS level 2 which illustrates the EUIS information system with the concept of micro services which
can be seen as follows.

![Conceptual Model of EUIS Level 1](image)

**Figure 2. Conceptual Model of EUIS Level 1**
Figure 3. Conceptual Model of EUIS Level 2

In the data architecture design phase, the following activities are carried out:

- Study of microservice concept literature
- Study of TOGAF-ADM framework literature to comprehensively understand the data architecture design. The phases in designing data architecture in TOGAF-ADM are:
  - Preliminary phase
  - Vision Architecture phase
  - Business Architecture phase
  - Information System Architecture phase
  - The Technology Architecture phase

In the Information System Architecture phase, research is only carried out until the design of application architecture analysis. Deliverables generated are Entity Relationship Diagrams (ERD), use case, data architecture, application system architecture, application architecture roadmaps.

Perform a Gap Analysis of the architectural design of the data generated with the existing data architecture at EUIS, so that a solution to the problem can be analyzed.

4. Analysis and Discussion

In this research, there is a gap between existing EUIS performance and expectations of expected EUIS performance. Problems related to the performance of the system being analyzed are the concept of a database that is still centralized in its business processes so that if there are obstacles in one business process, it will have an impact on other business processes. Therefore, a data architecture design was carried out that included the concept of decentralized data based on each business process.

The data architecture design framework used is The Open Group Architecture Framework (TOGAF). In the TOGAF framework itself, there is a part that is used to design architecture, namely the Architecture Development Method (ADM). ADM is more precisely categorized as an architectural process than an architectural framework or methodology [4].

Based on Figure 1, each circle has its activity. Every activity in the picture is interconnected and refers to the business requirements that have been prepared previously. By conducting the research stages described in section III, the application steps for compiling the data architecture using TOGAF-ADM are as follows:
In designing an enterprise architecture, preparation is needed to arrange the architecture capabilities. At this stage, the aim is to convince everyone involved in it that this activity is carried out to succeed in the architectural process. This phase also aims at how architecture can meet organizational goals.

**Phase Vision Architecture**
This stage carries out high-level requirements that contain the scope of development to be carried out. The company's vision and mission, as well as the concept of development carried out by the company, will be a reference in making business architecture at the next stage.

**Phase Business Architecture**
In this phase, the condition of existing business architecture is known, analyzed, and added according to the requirements obtained in the previous stage. Also at this stage, the business model and business scenario that is to be developed start to appear. Referring to the previous research, it is illustrated that the business processes of a tertiary institution in Indonesia are generally the same, which can be seen in Figure 4. Figure 5 is the architecture of the academic information system business processes that exist in EUIS which can be seen as follows.

![Figure 4. Academic Information System Flow](image)

![Figure 5. Business Process Architecture of Academic Information Systems](image)
There are many business processes in EUIS, one of which is the lecture and assessment process. Examples of use cases from business processes in lectures and assessments at EUIS are as follows:

![Use case diagram for lecture](image1)
![Use case diagram for assessment](image2)

**Figure 6.** Use case diagram for lecture  
**Figure 7.** Use case diagram for assessment

- Fase Information Systems Architecture
The purpose of this phase is to determine the type of data as well as the data that will be stored concerning the needs of the running business processes of the Institution that will use EUIS. Based on existing business requirements, data architecture can be arranged which can be seen in Table 1.
Table 1. Data architecture

The exist EUIS architecture system is still centralized, so the affecting performance in the data processing. The decentralized microservice architecture has been successfully designed. Some ERD examples have been made to illustrate the interrelationships of each data entity shown in Figure 8, Figure 9, and Figure 10.
Figure 8. ERD lecture schedule

Figure 9. ERD academic calendar

Figure 10. ERD curriculum
Fase Technology Architecture

At this stage, the relevant technology is determined for applications that can process data to be connected and integrated if there is a change between one data in one database with other data, according to the microservice concept. Figure 11 shows the conditions when many applications can be integrated with the data using Kafka message, which in theory Kafka can facilitate the integration process [12].

Utilizing Kafka messages can make it easier for developers to integrate one application with another application or there are additional new applications with the same database requirements. This can overcome different client conditions, namely:

- The client does not have a Legacy system and wants to use one or more of the services available at EUIS.
- The client has a Legacy system and wants to use existing data and still uses the Legacy system, but wants to use one or more EUIS services and the Legacy system on the client can be changed.
- As is the case with condition 2, but the legacy system owned by the client cannot be changed but the database can be accessed directly.
- The client has a Legacy system and only wants to use old data to then use the EUIS service
- Legacy systems on the client cannot be changed or added new services, so for this condition, it is fully recommended to move to the EUIS system.

With these 5 conditions, enterprise architecture that utilizes Kafka message technology can overcome the problem of conditions that exist on the client, for example, if the client has the 3rd condition, the client has a legacy system and wants to use one or several EUIS services, but the legacy system owned by the client can not be changed but the database can be accessed directly. So with these conditions, the solution offered can be done can be seen in Figure 12.
In Figure 12, Kafka connect which is a function on Kafka can change the changes in the data recorded in the Legacy database log into Kafka topic which can then be listened to by services A, B, and C.

After knowing the interrelationships in each data held, the next step taken is to create a technology architecture roadmap. The goal is to estimate how long it will take to develop a technology architecture that will be used at EUIS can be seen in Table 2.

| List of improvements                                      | Implementation period | Implementation plan                                      |
|------------------------------------------------------------|-----------------------|--------------------------------------------------------|
| The application is no longer monolithic but applies the    | 1 year                | Make a list of institutional needs for features that will be used to be |
| microservice concept                                       |                       | 1 business process has 1 service and 1 database        |
| The application has structured and integrated data         | 1 year                | The database in each business process is integrated and updated using the Kafka platform technology |
| Applications can be dynamic with the addition of features  | 6 months              | Create an endpoint list by separating the frontend and backend with the Rest API concept |
| EUIS can be integrated with the Feeder Dikti              | 6 months              | Maintain the features of Euis that have been integrated with the Higher Education Feeder so that it can be implemented in the future Euis (to be) |
| EUIS can be integrated with other applications             | 1 year                | Creating a database that is owned in every business process contained in EUIS can be used and used in other applications. |

5. Conclusion
TOGAF ADM is used to plan EUIS architecture in enterprise scale. To achieve the expectations of EUIS performance issues, this research designed an enterprise architecture that is more focused on designing the use of technology with the microservice concept, where previously centralized databases for all business processes are separated based on each business process. With the application of the microservice concept, it facilitates the process of application development, performance data and application performance and can be used for various universities, adding features, and makes it easier to integrate with other applications if the client already has an information system before. Togaf ADM can assist in planning architectural changes from monolithic to micro services by identifying several scenarios. Pusilkom UI currently has implemented this design with a client that has condition 2, so that further research can be tested for other conditions.

Acknowledgments
We would like to thank the development team of Enterprise University Information System, for Wida Sari, M.TI as the leader in the EUIS team. Special thanks are given to Yova Ruldeviyani, S.Kom., M.Kom., who has given full support and guidance so that this paper can be completed.
References

[1] Bagley, C. E. 2015. *Managers and the legal environment: Strategies for the 21st century*. Cengage Learning.

[2] Pusilkom UI. 2018. *Euis - Solusi Terintegrasi Untuk Kelola Administrasi Akademis* Pusilkom UI

[3] Budiman, K., Prahasto, T., & Kusumawardhani, A. 2018. Enterprise Architecture Planning in developing A planning Information System: a Case Study of Semarang State University. In *E3S Web of Conferences, 31*, pp. 11002.

[4] Yusuf Sanny, M., A Wahab Syaroni, D., & Suryana, T. 2012. Enterprise Architecture Planning Sistem Informasi Puskesmas Pasirkaliki. *Majalah ilmiah UNIKOM*.

[5] Bente, S., Bombosch, U., & Langade, S. 2012. *Collaborative enterprise architecture: enriching EA with lean, agile, and enterprise 2.0 practices*. Newnes.

[6] Tizzei, L. P., Nery, M., Segura, V. C., & Cerqueira, R. F. 2017. Using microservices and software product line engineering to support reuse of evolving multi-tenant saas. In Proceedings of the 21st International Systems and Software Product Line Conference-Volume A, pp. 205-214.

[7] Tupper, C. 2011. *Data architecture: from zen to reality*. Elsevier.

[8] Narimawati, U. 2008. Metodologi Penelitian Kualitatif dan Kuantitatif, Teori dan Aplikasi. *Bandung: Agung Media*, 9.

[9] Narkhede, N., Shapira, G., & Palino, T. 2017. *Kafka: the definitive guide: real-time data and stream processing at scale*. "O'Reilly Media, Inc.".