Design of a Cloud Based Information System For Education Institution using TOGAF ADM

Segaf Husein, Ahmad Nurul Fajar

Abstract: ***Cloud computing technology allows a service to be accessed from anywhere and anytime through the internet network, this technology can be utilized for organisations to encourage standardisation of business processes for all business units. Muhammadyah as one of the largest education institution in Indonesia currently operates more than 5000 schools from elementary to high school. In general, all schools have similar business processes that are run manually and have almost identical information system requirements. This condition causes no data structure standardisation, no data consolidation between one school and another and the inconsistency of information system development. These problems become the rationale for designing an information technology architecture model using the concept of cloud computing. Based on the results of the analysis on current conditions and using the chosen TOGAF framework, a cloud computing-based information technology architecture model is produced. The information technology architecture consists of vision architecture, business architecture, application architecture, data architecture and technology architecture. Research is expected to contribute to educational institution in Indonesia, especially as a reference in designing information technology architecture.***

Keywords: information technology architecture, TOGAF, cloud computing, education information systems

I. INTRODUCTION

Information technology has taken a very important role along with the development of recent times, the use of information technology has been considered a necessity in an effort to improve the effectiveness and efficiency of organisational operations so that by itself can increase competitiveness in the digital era. The rapid development of computational capabilities has led to digital transformation in the industry which is better known as the "Industrial Revolution 4.0". This revolution aims to transform industrial processes through digitalization and exploitation of new technological potentials [1].

Cloud computing technology as one of the main driver of Industry Revolution 4.0 allows a service to be accessed from anywhere and anytime through the internet network, this technology can be utilized for organisations to encourage standardisation of business processes for all business units. Carl Hewitt in [2] define that cloud computing technology is a technology where most of the processes and computing are located on the internet network so that it allows users to access the services needed from anywhere.

Due to the benefits offered, we have seen an increasing adoption level of cloud computing technology in industry, including thus in Indonesia [3].

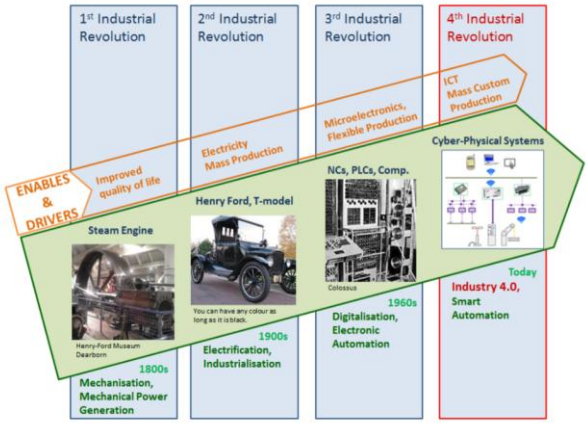

Fig. 1 Industrial Revolution 4.0 [1]

The information technology architecture in an organisation is a blueprint that explains how elements of information technology and information management work together as a whole. Thus, the implementation of an appropriate information technology architecture will greatly assist the achievement of organisation goals. The emergence of cloud computing technology adds further value to the design of information technology architecture for organisations, including educational institution.

Muhammadyah is one of the largest social organisation in Indonesia, the organisation aims to build a more developed and educated social and education system of society. In line with this goal, Muhammadyah has established hospitals, orphanages and places of education at the level of primary, secondary and tertiary education throughout Indonesia.

Table- I: Muhammadyah Operated Assets

No	Muhammadyah Assets	Count
1	Hospital	72
2	Kindergarten	4623
3	Elementary School	2.604
4	Junior High School	1.111
5	Senior High School	1.291
6	Universities	177

Revised Manuscript Received on February 10, 2020.
* Correspondence Author
Segaf Husein*, Information Systems Management Department, BINUS Graduate Program-Master of Information System Management, Bina Nusantara University, Jakarta 11480, Indonesia.
E-mail: segaf.husein@binus.ac.id
Ahmad Nurul Fajar, Information Systems Management Department, BINUS Graduate Program-Master of Information Systems Management, Bina Nusantara University Jakarta, Indonesia 11480, Jakarta, Indonesia.
E-mail: afajar@binus,.edu

In general, all Muhammadyah schools have similar business processes that are still run manually, hence similar information system requirements. The manual nature of the operation causes many issues for Muhammadyah, namely no process standardisation, no data consolidation between one school and another, and inconsistency of information system development. Issues also occurs on day to day activities at school, from the lack of parent involvement in the teaching and learning process, ineffective manual administration process, to the limitation of medium to bridge communication between school and parents

Based on the above background, this research aims to design an information technology architecture model that is in accordance with Muhammadyah conditions and needs. Area of discussions covered in this paper includes:

1. How is the information technology architecture model based on cloud computing technology that is suitable for the needs of Muhammadyah
2. What are the components of cloud computing-based information technology architecture for Muhammadyah education institution
3. Define services provided by cloud computing providers in the information technology architecture model.

The research methodology used is TOGAF Architecture Development Method (TOGAF ADM) methodology [4], the ADM phase is carried out through phase 4 - Architectural Technology.

II. LITERATURE REVIEW

A. Enterprise Architecture

According to [5], corporate architecture is a strategic information that defines the company's mission, as well as what information and technology is needed to achieve that mission. An organisation architecture consists of basic architecture, goal architecture and structured planning to achieve goals. The basic architecture of an organization is an existing architectural condition, for example the network architecture. Destination architecture is the architecture of the company to be built (to-be). To achieve the expected architecture, a proper plan and structured steps is needed.

Information technology architecture is the basic organisation of a system intensive in software. A system is software intensive because the most prominent part of an information technology architecture is its application, the part that allows users to do business work. [6] There are a number of already established EAF in use today, some of these frameworks were developed for very specific areas, whereas others have broader functionality.:

1. Zachman Framework for Enterprise Architecture
2. Department of Defense Architecture Framework (DoDAF)
3. Federal Enterprise Architecture Framework (FEAF)
4. Treasury Enterprise Architecture Framework (TEAF)
5. The Open Group Architecture Framework (TOGAF)

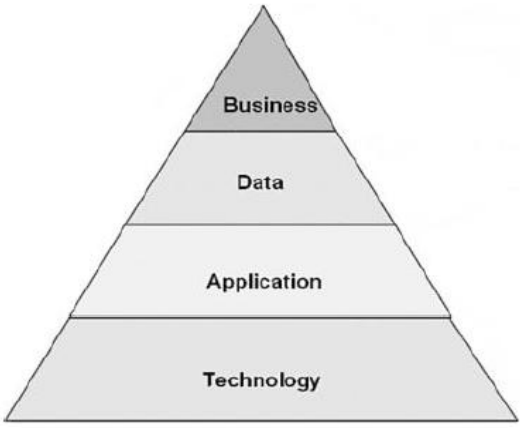

Fig. 2 Layer of Enterprise Architecture [7]

Faisal Binsar and Nilo Legowo [8] explained that There are several benefits obtained in building an enterprise architecture (EA):

1. Streamlining business processes: the basic advantage of building an EA is to find and reduce repetition in business processes. The reason for this repetition is due to different organisational views on data or business processes. The basic approach to building an EA is to focus on data and processes.
2. Reducing the complexity of information systems: a framework reduces the complexity of information systems. This was achieved through an identification process.
3. Enabling integration via data sharing: EA identifies data standards for sharing. For example, most companies have customer and market data, but the data is stored in different databases. EA forms the compatibility of the data used (share). Data compatibility provides a standardized data store in a data warehouse for market research and analysis. A good architectural design not only facilitates the company's value chain but also can provide the infrastructure needed to connect the value chain between companies.
4. Speed up the evolution of new technology: client/server technology revolves around understanding data and the processes that shape and access it. As long as the EA is structured based on data and processes and there is no repetition on the same thing, the client/server technology can run well in an information system in a company or institution

B. TOGAF

TOGAF [4] is an industry standard for architectural development methods and a resource base that can be used freely by any organisation that wants to develop enterprise architecture to use in its own organisastion. TOGAF has been developed and evolved continuously since the 90s by representatives of several leading user and information technology vendor organisations working together in The Open Group's Architecture Forum.

TOGAF provides a variety of methods and tools to help companies prepare, develop, use and maintain the company's architecture. TOGAF is created and continuously improved based on the best practices of various companies and organisations. TOGAF supports four types of enterprise architecture, namely business architecture, data architecture, application architecture and technology architecture.

1. Business architecture or business process architecture defines the business strategy, mastery, organisation, and key business processes of an organisation.
2. Application architecture provides individual application system specifications for distribution, interactions between application systems and relationships at the core business processes of the organisation with a framework for services as a business function for interaction.
3. Data architecture describes the logical organisational structure and physical data associated with resource management.
4. Technology architecture, describes hardware, software and network infrastructure needed to support the core deployment, mission critical applications

TOGAF Architecture Development Method (ADM) is part of TOGAF architecture framework that provide clear guide lines for IT development lifecycle.

C. Cloud Computing

Peter Mell and the Grance Team from the National Institute of Standards and Technology (NIST), the Information Technology Laboratory define cloud computing as a model that facilitates the availability and configuration of services in the form of software, networks, servers, storage media and applications. A service can be installed and removed easily [9]. The cloud computing model has five main characteristics, namely On-demand self-service, Broad network access, Resource pooling, Rapid elasticity and Measured Service. In the definition revealed by [9], the concept of distributed systems (grid computing) and virtualisation is emphasized. In a distributed system, division of tasks occurs in carrying out a process. As an example in the search process in search engines, like Google or others. When visitors perform a search request, the search engine will divide the search task into several machines (processors), so that search results can be generated faster and in a more efficient way.

Rajkumar Buyya, Yeo and Venugopal [10] define that a cloud is a type of parallel and distributed system consisting of a collection of interconnected and virtualised computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers. And when viewed from its development, cloud computing consists of 4 (four) models, namely Private cloud, Community cloud, Public cloud and Hybrid cloud [10].

III. METHODOLOGY

The research carried out following steps in TOGAF ADM framework, ADM was applied to build an architecture that aligns business needs with information technology in organisations. ADM consists of one preparation phase, 8 main phases and a process that manages the entire phase.

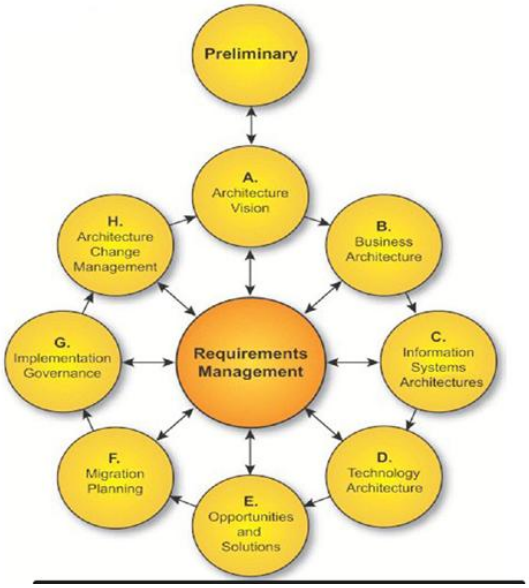

Fig. 3 TOGAF ADM Phases [4]

Data collection process for the research was done through literature study, observation and interview

1. Literature study done by collecting data and information related to the topic of this paper, literatures are used as a reference mainly collected from books and research journals in the topic of enterprise architecture, cloud computing and TOGAF Architecture Framework
2. Observation done in Muhammadyah school to observe current condition and to collect required information from the field.
3. Interview was done to get the information directly from primary source of the system namely Muhammadyah education stakeholders

In the scope of this paper, ADM phase was carried out through phase 4 - Technology Architecture:

A. Architecture Vision

At this stage, we aims to identify the organisation vision which later will be used to create a uniform perspective on the importance of enterprise architecture to achieve the objectives of the organisation.

B. Business Architecture

Define the initial conditions of the business architecture, identify business main drivers and needs, determine the desired business model and activity based on a business scenario. At this stage general tools and methods for modeling such as: Business value chain, Use case Diagrams, Activity Diagrams and Sequence Diagrams can be used to build the required models.

C. Information Systems Architecture

At this stage, the emphasis is more on the activity of how the information system architecture is developed that includes both application architecture and data architecture.

Application architecture have to reflect the business needs identified in previous step while data architecture focuses more on how data is defined, stored and distributed among the stakeholders.

D. Technology Architecture

Building the desired technology architecture, starting from determining the type of technology candidate needed from both software and hardware perspective.

IV. DISCUSSION RESULT

After analysing existing conditions of teaching and learning process at Muhammadyah school and applying steps in TOGAF ADM, the following results were obtained:

A. Architecture Vision

The vision and mission of the Muhammadyah Education Institution refer to the Statutes and By-Laws. The characteristics of the education information system developed must refer to the vision of Muhammadyah digital education as follows:

1. The first step to improve the quality of education of Muhammadyah schools that is evenly distributed throughout Indonesia
2. A mean to supports the quality standards in Muhammadyah education process throughout all regions in Indonesia
3. Characterize Muhammadyah with values of modern Islamic education
4. Become a legacy that supports the development of new generation in Muhammadyah school environment

B. Business Architecture

The main business activities in Muhammadyah schools are in the academic section where there are 4 main activities that provide competitive advantages, namely:

1. Learning Management System
2. Student Services
3. Teacher Competencies
4. Commitment and Professional Responsibility

While the supporting activities are activities related to process and quality improvement which include administration, financial management, and human resource management. The following figure explains the value chain of the business architecture of schools managed by Muhammadyah:

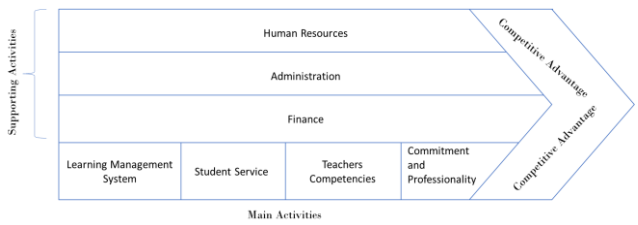

Fig. 4 Business Value Chain

C. Application Architecture

Figure 5 illustrates how the position of an application as a service to be placed on the internet network can be accessed by all Muhammadyah education stakeholders.

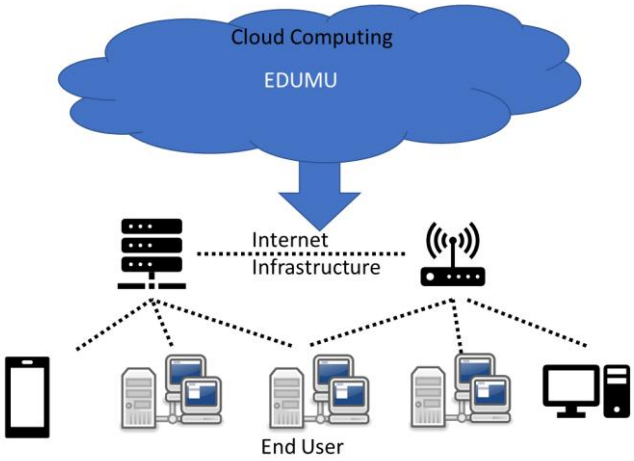

Fig. 5 Cloud Computing Architecture

Features that are developed must be adapted to the main business processes described as follows:

1. Learning Management System

- Discussion forum feature to facilitate discussion between education stakeholders
- Online assignment feature allows parents to monitor their children learning progress
- Online exam feature help school to process student exams
- Online learning materials allowing students to study anywhere

2. Student Services

- Student grades feature to stimulate the enthusiasm of students and parents in an effort to improve academic achievement
- Realtime and class attendance features allow parents and teachers to monitor student attendance at school and class in realtime
- Student tracking feature to monitor student activities outside the school parameters

3. Teacher Competencies

- Online learning materials to increase teaching skills
- Digital certification module to help teachers obtain required certification
- Online exam features as a test tool to improve teacher competency

4. Commitments and Professional Liability

- Teacher report card contains the number of teaching obligations, and other supporting information

As a cloud based application, the system is designed to have 2 type of user interfaces:

1. Mobile user interface running in Android based mobile device
2. Web based user interface to access the system through a web browser

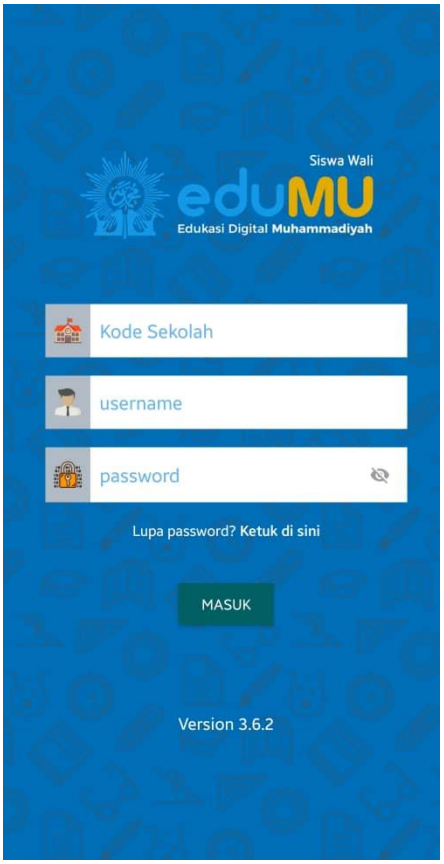

Fig. 6 Login Page Design for Android User

D. Data Architecture

One of the key component during the development of an enterprise solution is the development of data architecture, many things must be prepared and planned carefully in regards with how the data is stored and distributed.

The following were identified as main data required by Muhammadyah education information system:

Table- II: School Data

Field	Field Name	Type	Width	Notes
1	ID	Character	10	School ID (primary key)
2	Name	Character	25	School Name
3	No of students	Numeric	4	
4	TA	Numeric	4	Academic Year
5	Address	Character	50	
6	Website	Character	50	

Table- III: Students Data

Field	Field Name	Type	Width	Notes
1	ID	Character	10	Students ID(primary key)
2	Name	Character	25	Name Murid
3	Gender	Numeric	4	
4	DOB	Nu meric	4	Date of Birth
5	Address	Character	50	
6	Religion	Character	20	

Table- IV: Parents Data

Field	Field Name	Type	Width	Notes
1	ID	Character	10	Parents ID (primary key)
2	Name	Character	25	
3	DOB	Numeric	4	Date of Birth
4	Address	Character	50	
5	Religion	Character	50	
6	Phone	Character	20	
7	Email	Character	25	

Table- V: Teachers Data

Field	Field Name	Type	Width	Notes
1	ID	Character	10	Teachers ID(primary key)
2	Name	Character	25	
3	Gender	Character	10	
4	DOB	Date Time	4	Date of Birth
5	Address	Character	50	
6	Religion	Character	50	
7	Entry Year	Numeric	4	
8	Status	Character	20	
9	Phone	Character	20	
10	Email	Character	25	

Table- VI: Class Data

Field	Field Name	Type	Width	Notes
1	Class	Character	10	Class ID
2	Guardians	Character		
3	School	Character	25	School Name
4	No. Of Students	Numeric	4	

Table- VII: Employee Data

Field	Field Name	Type	Width	Notes
1	ID	Character	10	Employee ID (primary key)
2	Name	Character	25	
3	Gender	Character	10	
4	DOB	Date Time	4	Date of Birth
5	Address	Character	50	
6	Religion	Character	50	
7	Entry Year	Numeric	4	
8	Status	Character	20	
9	Phone	Character	20	
10	Email	Character	25	

Table- VIII: Schedule Data

Field	Field Name	Type	Width	Notes
1	Subject	Character	10	
2	Teacher	Character	25	
3	Class	Numeric	4	
4	Day	Character	15	
5	Start Time	Time		
6	End Time	Time		

Table- IX: Academic Calendar Data

Field	Field Name	Type	Width	Notes
1	Calendar	Character	10	Academic Year
2	Event	Character	25	
3	Curiculum	Numeric	4	

E. Technology Architecture

The success of the development of a cloud based solution is greatly influenced by the technology used. Muhammadyah education information system is designed as a Software as a Service (SaaS) solution. Each service will be connected to a presentation component that manages the display of applications in various media, such as browsers and mobile phones. In addition, there is an API (application program interface) needed to connect applications with other applications that might be developed by each school independently.

In terms of the design of information technology infrastructure architecture model, Muhammadyah education information system is designed following the Market-oriented Cloud Architecture model proposed by Rajkumar Buyya, Yeo and Venugopal [10] where there are 4 (four) main layers namely the machine layer or physical devices, virtual machines (VMs) layer, the SLA Resource Allocator layer and finally the user layer.

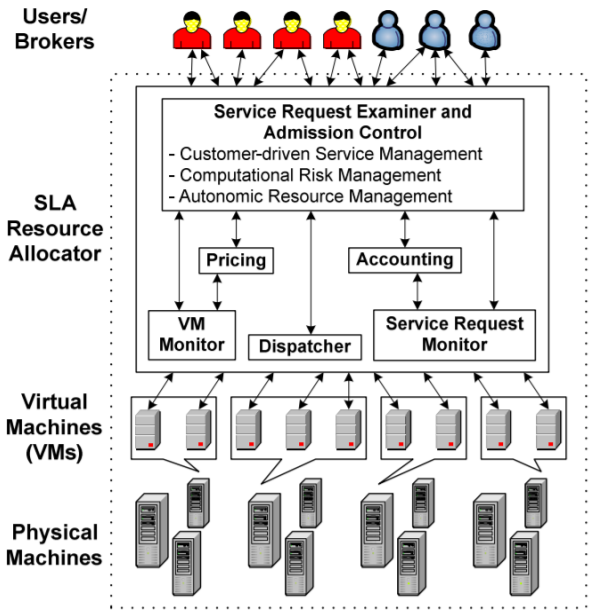

Fig. 7 High Level Market Oriented Cloud Architecture [10]

- **Layer 1** is the physical infrastructure which is the most basic part of the information technology architecture. Physical infrastructure in the form of application servers includes servers for data processing, databases, web servers and other types of servers required by each application. Server resilience in cloud-based architecture greatly affects the quality of services produced. What's more to serve the entire Muhammadyah school of more than 5,000. To increase the resilience of the server, grid technology can be used where each computing process can be run (executed) by several servers at once to be able to improve the quality of service.
- **Layer 2** has Virtual Machines (Virtual Servers). The concept of virtual machine or virtualization will increase the availability of IT services and will save the amount of physical infrastructure needed. Virtualization technology also allows each client or service user to virtually have full control over their own server, even though physically having to share resources with other clients.
- **Layer 3** is the SLA Resource Allocator which is part of the cloud architecture whose job is to manage the availability of services for each user. This section is the part that connects applications, information systems or services

Provided by cloud providers with consumer clouds, that is the stakeholders of Muhammadyah education instituion. This section is also responsible to receive service requests from users, analyse the eligibility of these requests and finally respond to the requests.

- **Layer 4** Users of the system, which are all Muhammadyah education institution stakeholders, such as schools, students, guardians of students, or teachers and employees of Muhammadyah education institutions. Users can submit a service and conversely users can also propose termination of a service if it is not needed.

The application will be hosted in Amazon Web Services that have a proven technology to ensure security supported with strong infrastructure for future scalability

V. CONCLUSION

Muhammadyah education institution is looking to standardise their business process throughout their entire operated schools in Indonesia. It is underlined that the education information system developed must be able to support the vision of Muhammadyah in the implementation of digital education.

Based on the results of discussions and research of this paper, it can be concluded briefly that:

1. By using the TOGAF ADM, an IT architecture model has been designed for Muhammadyah education institution in Indonesia and is in accordance with the organisation vison and mission. The resulting IT architecture consist of architecture vision, business architecture, application architecture, data architecture and technology architecture.
2. Leveraging the advantages obtained by using cloud computing technology, the resulting IT architecture is expected to solve the problem cuurently faced by Muhammadyah such as the absence of data consolidation and standardisation, and inconsistencies in the development of information systems.
3. To run the system efficiently, the information technology architecture that is most suitable for the application is a service-based architecture and adopting the virtualisation and grid computing concept to handle expected large volume of data transaction.

Further study is required to evaluate the effectiveness of the proposed system which can be done later after implementation phase.

ACKNOWLEDGMENTS

The authors of this paper would like to acknowledge Mr. Rizky Andrika, Deputy Treasury of Muhammadyah Basic Education Council, for his support during the research of this paper

REFERENCES

1. Rojko, A. *Industry 4.0 Concept: Background and Overview*. iJIM – Vol. 11, No. 5. 2017.
2. C. Hewitt, "ORGs for scalable, robust, privacy-friendly client Cloud Computing," IEEE internet computing, vol. 12, no. 5, pp. 96– 99, Sep. 2008.
3. F. Wildana, "Cloud Computing Implementation in Several Government Institutions", Jurnal Masyarakat Telematika dan Informasi, vol. 8. No. 2. pp. 97-108.2017
4. TOGAF, "TOGAF Standard Version 9.2" Evaluation, 2018. Available: https://www.opengroup.org/togaf.
5. J. J. Andersen, "Enterprise Architechture a.k.a. Business- and IT-architecture," Agenda, 2008.
6. L. Urbaczewski and S. Mrdalj. " A Comparison of Enterprise Architecture Framework". Issues in Information Systems, Volume VII, No. 2, 2006
7. N. E. Hewlett, "The USDA Enterprise Architecture Program," in PMP CEA, Enterprise Architecture Team, USDA-OCIO, .
8. F. Binsar and N. Legowo, "Design of Cloud Computing Outpatient Registration Model Through SMS Messages at Hospitals using TOGAF ADM". International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-5, January 2020
9. P. Mell and T. Grance, "The NIST Definition about Cloud Computing." National Institute of Standards and Technology, 2009.
10. R. Buyya, C. S. Yeo, and S. Venugopal, "Market-oriented cloud computing: Vision, hype, and reality for delivering it services as computing utilities," in 10th IEEE International Conference on High Performance Computing and Communications, 2008. HPCC'08, 2008, pp. 5–13.

AUTHORS PROFILE

Segaf Husein, is currently a master student of information systems management at Binus University. In his professional life, Segaf work as a Technical Sales Consultant for a leading industrial software company. In this role, Segaf help organization to accelerate digital transformation by exploiting the power of digitalisation to tackle the business challenges throughout full asset lifecycles from creation (Engineering, Procurement, & Construction) to operation and maintenance especially in Process and Power Industry.

Dr. Ahmad Nurul Fajar, Doctore in Computer Science, graduated from Faculty of Computer Science University of Indonesia (UI) in 2014. In 2001, he is graduated from Gunadarma University majoring in Informatics. Master of Science Informatics was completed in 2004 at Bandung Institute of Technology (ITB). Currently, he is the Faculty Member of Binus Graduate Program, Department of Master in Information System.**,** Research Interest in Software Engineering, Software Development, Information System Analysis and Design, Business Process, and Service Oriented Architecture .His email is afajar@binus.edu