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Optimization of Student Competency Application Architecture Using Service Oriented Architecture (SOA)

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ABSTRACT

Digital transformation in the Industry 4.0 era requires higher education institutions to be able to integrate various information systems adaptively to support the achievement of student competencies in real time. The main problems faced are fragmented assessment systems, skill tracking, and career development services that hinder comprehensive evaluation and personalization of learning. This study aims to design an application architecture based on Service Oriented Architecture (SOA) that can improve interoperability between systems in the higher education environment. The research method used is Design Research Methodology (DRM), which includes the stages of problem clarification, descriptive studies, and prescriptive testing of the architectural design. The results of the study show that the SOA architecture built is able to integrate competency assessment services, career information, and reporting that are directly connected to the needs of the industrial world. This system supports the use of APIs, microservices, and modern communication protocols such as JSON/XML to ensure flexibility and scalability. In conclusion, the application of SOA in the student competency information system not only improves the efficiency and reliability of data management but also supports data-based decision making and strengthens the link and match between higher education and the world of work.

Keywords: Industry 4.0, SOA, information technology architecture, student competencies, universities.

INTRODUCTION

Higher education institutions face challenges in integrating various system services and information technology with the implementation of the Industry 4.0 framework, especially the implementation of the latest methodologies [1][2]. Every university must realize that implementing the development trend of science and information technology in the era of Industry 4.0 can have a positive impact. In addition, competition between universities can increase along with the development of science and information technology [3]. Regarding the era of industry 4.0, every institution, including universities, needs to pay attention to the management of data and information produced in real time with various services [4], So it can be said that following the development of science and information technology trends is one of the key elements in the Industry 4.0 era [5][6]. Other key challenges specifically for universities are adapting to the technological infrastructure used for higher education data collection, processing, and distribution, including academic community entities; Higher education infrastructure functions not only as a technical support tool, but also as a practical link to reform data processing in various sectors/fields [7]. The positive impact of technological advances in the 4.0 era is that it requires universities to meet the demands of managing a variety of different technology services and applications. The solution that can be done is the application of Service-Oriented Architecture (SOA). The SOA service-focused architecture is a new approach that meets the needs of distributed and interconnected computing, is standards-based, and is protocol-agnostic [8][9]. SOA can create an ecosystem because all services can be interconnected with each other in an integrated manner [10]. The SOA paradigm is a conceptual architectural framework that facilitates change, allowing business processes to adapt flexibly [11]. SOA provides adaptive integration services and service reutilization thanks to its modular service-based architecture, and provides transparency by combining various applications. Through this approach, an integrated set of information technology

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(IT) resources remains accessible despite the presence of a variety of technology services, programming languages, functionality, and other platforms[12] [13].

The era of Industry 4.0, with the digitalization of various services, has changed the perspective of all educational institutions and stakeholders. [14]. One form of digitalization is an application that presents information about the achievement of student competencies in higher education, which is very crucial and has an impact on student competitiveness and the reputation of universities in the industrial world. Data on the achievement of competencies of student graduates is very crucial, considering the difference in views on the concept of diverse graduate profiles.[15]Likewise, the views and expectations of the industrial world and prospective workers about the desired competencies and suitability for various labor market needs [16].

Fajar, A. N., Nurcahyo, A., & Sriratnasari, S. R. (2018). "SOA System Architecture for Interconnected Modern Higher Education in Indonesia." This study discusses the importance of implementing Service-Oriented Architecture (SOA) in the higher education system in Indonesia to support the integration of fragmented academic information services. With a service-based approach, SOA can connect different systems in the campus environment, such as academic management, attendance data, grades, to general administration systems. This study concludes that SOA enables system interoperability and flexibility, supports connectivity between internal and external systems, and opens up opportunities for integration with industry. Niknejad, N., Ismail, W., Ghani, I., Nazari, B., Bahari, M., & Hussin, A. R. B. C. (2020) "Understanding Service-Oriented Architecture (SOA): A Systematic Literature Review and Directions for Further Investigation"

This article is a systematic literature review on SOA covering approaches, technologies, benefits, and implementation challenges in various sectors, including education. This study identifies that SOA has an important role in creating reusable, easy-to-integrate, and cost-effective systems. In the context of education, it is stated that SOA can improve operational efficiency and support personalization of data-driven learning.

The novelty of this research lies in the development of a Service Oriented Architecture (SOA)-based application architecture that is specifically designed to optimize the interoperability of student competency achievement systems in higher education environments. Different from previous studies that only focused on the development of general academic systems or administrative data integration, this study offers a conceptual and implementative approach that unifies competency assessment systems, skills development tracking (both academic and non-academic), and career services in one integrated platform. In addition, the implementation of microservices and APIs in this design also provides high flexibility for future service development, including the potential for integration with artificial intelligence (AI) technology for predictive analysis of student competency data. The purpose of this study is to design and develop a Service Oriented Architecture (SOA)-based student competency achievement application architecture that is able to integrate various higher education information systems efficiently and adaptively.

This study specifically aims to analyze the integration needs between competency assessment systems, skills development tracking, and learning support services in higher education environments. Furthermore, this study aims to design an SOA architecture model that can connect academic and non-academic systems to support the personalization of student competency development. Through the implementation and testing of the architecture, this study also aims to evaluate the effectiveness of real-time information service integration. In addition, this study is expected to provide real contributions to the development of information technology infrastructure in higher education, especially in order to improve the quality and competitiveness of graduates through an integrated competency recording and reporting system.

2. RESEARCH METHODS

In this study, the method applied is Design Research Methodology (DRM), by conducting a direct analysis of the need for information technology (IT) integration with various applications in processing data to become information in educational institutions.

The stages of the research method implemented, namely DRM, DRM as a useful and practical methods that can meet the research objectives and are the main concern of the researchers. [17][18][19] This method can be used to evaluate success criteria according to measurable research objectives.[20], as explained in the following Figure 1:

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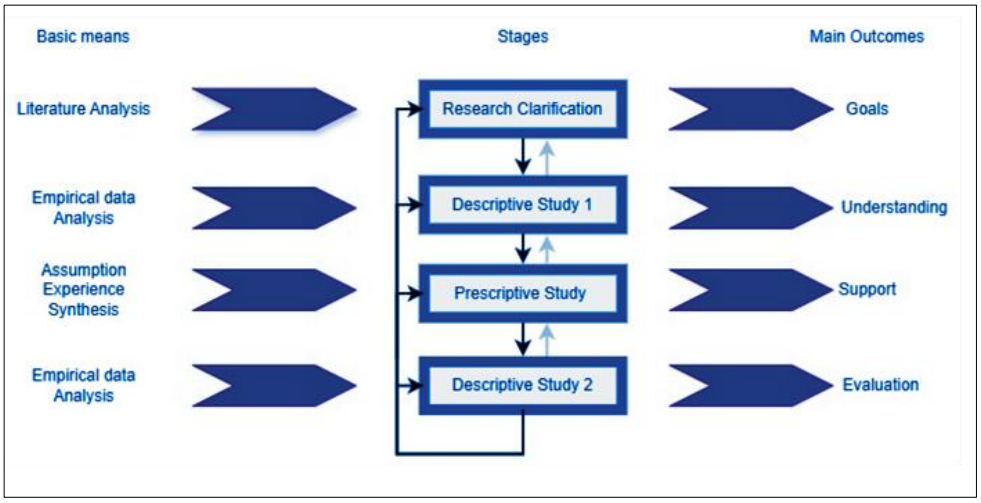

Figure 1. DRM

Referring to figure 1 is described in table 1 as follows:

Table 1: DRM Description

Research Clarification	The process of studying problem phenomena and literature studies.
Descriptive Study I	1. The literature review process related to technology devices and student competency applications. 2. The process of studying university infrastructure. 3. The process of studying the forms of data validation. 4. The process of studying the architecture of computer systems related to educational applications, especially in academia. 5. The process of comparing the architecture of computer systems. 6. The process of study and comparison of modeling methods that support the creation of computer system architecture.
Prescriptive Study	Establish a conceptual architecture for the validation of various application services using SOA.
Descriptive Study II	Testing SOA implementations

3. RESULTS AND DISCUSSION

Implementation of SOA in Student Competency Applications

The implementation of SOA is built using various service modules, including student competency achievement services, career opportunity services, and industry services (job fair). Focus on competency services, mapping student competencies, and recording information on non-academic activities, such as organizational activities that they participated in while actively studying.

The SOA-based student competency application integrates the process of inputting competency achievement data from students with evaluations that use predetermined criteria and reporting of competency results that are published in real time, and the institution can monitor, validate, and obtain information on the development of student competencies and can provide feedback directly. All of these services are configured to integrate using Application Programming Interfaces (API) that allow interoperability between different systems of services or protocols.

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Scalability and flexibility are the main advantages of this architecture. Colleges can develop new services, such as integrations with industry certification platforms or job marketplaces, without making changes to the core architecture. Universities can use integrated data analytics to analyze trends in student competency achievement that help refine the curriculum and learning strategies. Through this SOA design, universities can improve the preparation of student graduates to adapt to the needs of the world of work market by their competencies. The implementation of SOA in the application of university student competency achievement is as shown in Figure 2:

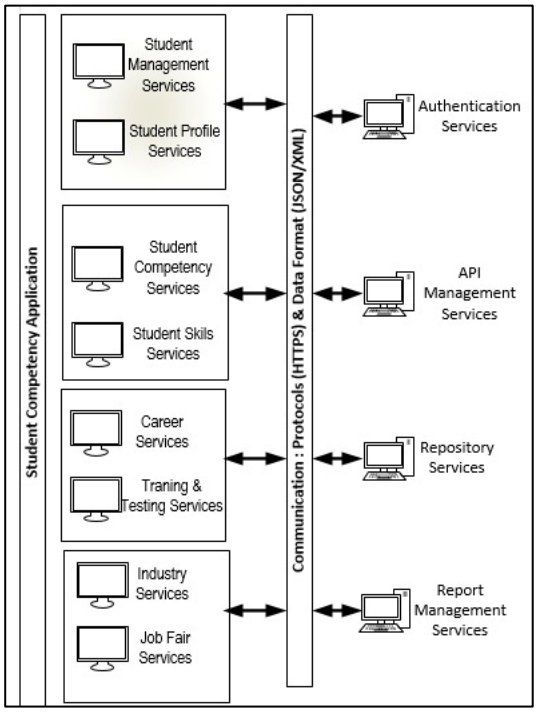

Figure 2. SOA Implementation

Figure 2 explains the implementation of SOA on which consists of 2 main layers, namely the Consumer layer and the Service layer. The conceptual diagram of the architecture reflects the interaction between components and the interconnectedness of SOA implementation in the student competency information system and others.

Consumer Layer

This layer is used for users or interfaces that are directly involved with students and other interested parties. This level consists of a variety of software-based facilities that provide certain capabilities to stakeholders. Student service operations facilitate the governance of student personal data statistics, academic activity profiles, and achievement of competencies or non-academic such as hard skills and soft skills, as well as other skill development services, with a focus on the development of technical and interpersonal skills. Career services facilitate job prospects by offering details about job opportunities, mentoring, counseling, and a platform for job recruitment, bridging students with potential job opportunities. This SOA-based application architect connects students to the industrial world through industry services, including internships, collaborative ventures, and partnerships. To improve skills, services are available that offer training and exam rooms for students' interests and talents. All of these services are designed and designed to help students prepare to face the challenges of the world of work and foster a sense of competitiveness so that the growth of their competencies is maximized according to the needs of the world of work.

Service Layer

Back-end services are located at this layer to support applications in the Consumer Layer. The Service Layer works with specific communication protocols and data formats, such as HTTPS and JSON/XML, which serve to ensure maximum interoperability between services in higher education for students and stakeholders. The Authentication Service functions to manage user authentication and authorization and ensure that only registered users can access

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the application so that data and systems are safeguarded. There are also services in the form of application programming interfaces (API) management that allow communication and interoperability between various applications from external or internal sources. The repository service functions to store important data, such as student competency documents and student training data, thus ensuring the accessibility and reliability of this data. Regarding the need for evaluation and analytics, the existence of reporting management services supports the creation of reports and data analysis, so that universities can evaluate student competencies and student performance more effectively. With the existence of SOA-based integrated services, a system that is safe, reliable, flexible, and supports decision-making oriented to accurate and measurable data or information is created.

Microservices in Student Competency Application

The existence of a microservices architecture can divide applications into independent services that can be developed, managed, and deployed separately, as seen in the following figure 3:

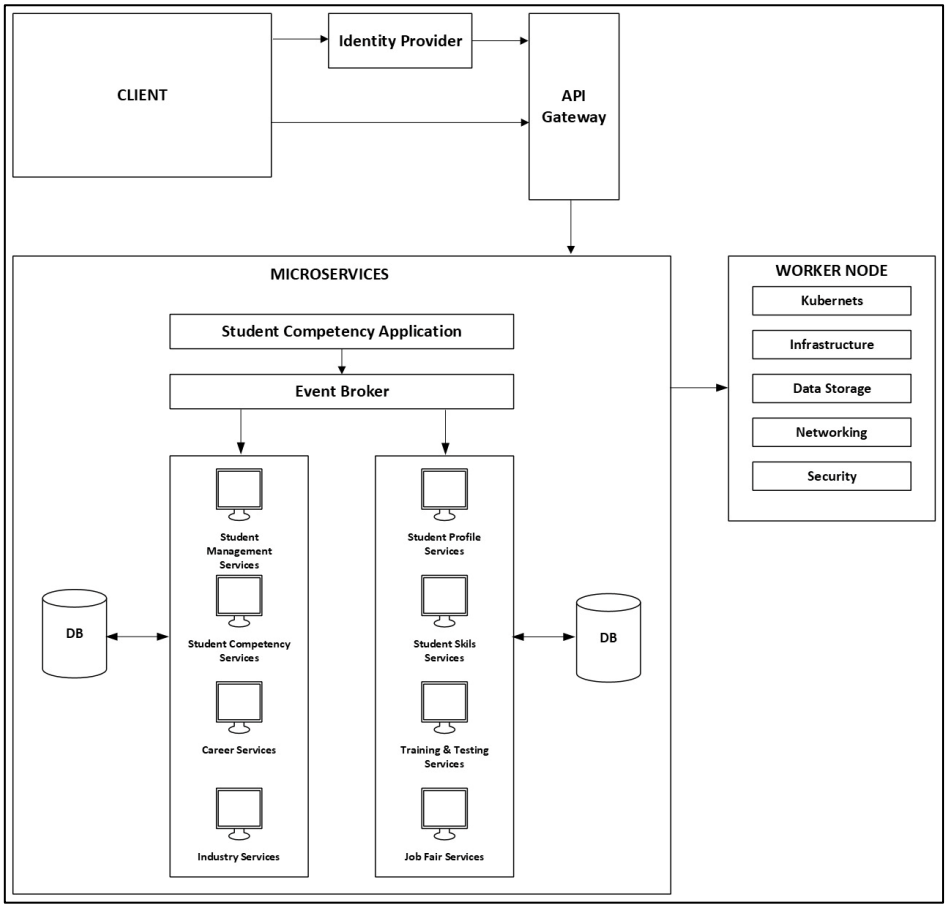

Figure 3. Microservices in Student Competency Application.

Figure 3. Explaining the architecture, namely microservices, for student competency applications to provide services that are distributed with other applications in higher education. Clients are student users, lecturers, or stakeholders who access student competency applications, Clients interact with authentication mechanisms. Identity providers are responsible for managing user authentication, ensuring security, and authorizing access to applications. This component uses standard security protocols such as OAuth or OpenID Connect, and is responsible for providing an authentication token to the client. Meanwhile, API Gateway has a function as the main gateway for all requests from clients. Event Broker which is a middleware component that handles communication between microservices. The architecture also supports event-based communication patterns, such as publish/subscribe or event streaming, so that all services can interact asynchronously without directly relying on each other, while Worker Nodes are the infrastructure on which microservices run.

The results of testing on the architecture and applications built and the implementation of SOA can show indicators that the application meets the needs of the user and that the integration of SOA-based services is working well.

1. Functional Testing: Successfully manage student competency achievement data as well as accurate recording, evaluation, and reporting.

2. Integration Testing: SOA-based services are proven to support interoperability between application modules, integration with academic systems, SKPIs, and portfolio media.

3. Performance Testing: Successfully demonstrated fast response times and were able to handle multiple users simultaneously.

4. Security Testing: Proven to protect student and stakeholder data from unauthorized access.

5. Scalability Testing: SOA implementation provides an opportunity for future applications to be developed or modified as needed without having to overhaul the main architecture.

This study has several limitations that need to be considered. First, the application of the Service Oriented Architecture (SOA) in this study is still limited to the environment of certain higher education institutions, so the generalization of the results to institutions with different technological infrastructures still needs to be tested further. Second, application and architecture testing are still focused on the technical aspects of integration and functionality, while user aspects such as user experience (UX) and human resource readiness in managing the system have not been the main focus of this study. Third, the absence of integration with external systems based on artificial intelligence (AI) or big data analytics that can provide predictive analysis of student competency development is also a limitation.

For future research, it is recommended that the development of this SOA architecture be expanded to various types of educational institutions with more diverse infrastructures to test its flexibility and scalability. In addition, further research can also explore integration with AI technology to support predictive competency development analysis and more personalized learning recommendations. A more in-depth study of socio-technical aspects, such as institutional readiness, user training, and acceptance of technology by academics, can also be an important direction so that the implementation of this architecture is truly effective and sustainable in supporting the digital transformation of higher education.

4. CONCLUSIONS

The application of the SOA method in the creation of information technology architecture in higher education has a positive impact on the processing of student competency achievement data that is distributed from various data sources with different protocols or platforms. The architecture, built as a flexible service, supports the integration of academic and non-academic data in real time and provides accurate and relevant information to the academic community and other stakeholders. SOA-based applications or applications can facilitate the delivery of student competency achievement data to stakeholders, including the industry/work world. This supports the achievement of the concept of link and match between the world of higher education and the world of industry/work, by the demands of the digital era and Industry 4.0. This research can make a significant contribution to the development of SOA-based architectures and applications in the higher education environment, as well as open up opportunities for further development, especially integration with artificial intelligence (AI) technology.

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