National archival platform system design using the microservice-based service computing system engineering framework

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ABSTRACT

Archives play a vital function concerning the dynamics of people and nations as an instrument to treasure information in diverse domains of politics, society, economics, culture, science, and technology. The acceleration of digital transformation triggers the implementation of a smart government that supports better public services. The smart government encourages a national archival system to facilitate archive producers and users. The four electronic-based government system (SPBE) factors in the archival sector and open archival information system (OAIS) as a data preservation standard are the benchmarks in developing this study's national archival platform system. An improved service computing system engineering (SCSE) framework adapted to the microservice architecture is used to aid the design of the national archival platform system. The proposed design met the four-factor service design validation of coupling, cohesion, complexity, and reusability. Also, the prototype suggests what resources are needed to put the design into action by passing the performance test of availability measurement.

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1. INTRODUCTION

The acceleration of digital transformation brings a paradigm shift resulting in the necessity to implement electronic-based archives to run the governance system. The transition drives organizations to adapt business services by employing digital technology to transform the value-creation procedure in resulting positive impact of expected results [1]. As the organizer of the national archives, the National Archives of the Republic of Indonesia (ANRI) has the authority to implement an electronic-based archive system. Kharisma and Agustina [2] states that the archives field's digital transformation is transferring conventional archival media into digital archives, a type of digitization. Digitization, as a catalyst for digitalization, encourages the implementation of [3] regarding the archival electronic-based government system (SPBE), which holds the concept of servitization in disseminating digital archives to boost the digital transformation strategy. The foundation for building electronic-based archives includes the SPBE principles architecture in national archives, which comprises integrated, dynamic, compliant, and comprehensible, as shown in Figure 1.

The integrated principle contained in the SPBE in the archives sector is to become a unified whole that is easy to understand and use comprehensively, so an architectural concept is needed that facilitates the integration of complete data. The current problem with ANRI is the need for an integrated national archive system. The ANRI archive system is divided according to its management function of the Dynamic Archival Information System (SRIKANDI), the static archive management information system (SIKS), the National Archives Management Information System (SIKN), and the national archives information network (JIKN). Those systems are not fully integrated, which induces the input process on each system still conduct the recurrence process. In [4] employs a service-based computing method that supports the integrated principle by providing a service architecture concept that easily incorporates different business services. Huang and Meng [5] developed a record administration service system utilizing service architecture in transmitting data. The integrated principle can be fulfilled by applying the service architecture concept.

A mapping between business and IT services needs is required to fulfill the requirement for integrated principles in every business service. The service identification is essential to provide proper mapping resulting in smooth alignment in both services. Service computing system engineering (SCSE) is a methodology that incorporates a service computing framework in a series of life cycles that fosters the systematic and persistent design and implementation of systems that can specify the requirements of IT services and business services [6]. Accordingly, innovations in archival services can be realized by mapping the necessities of IT and business services.

The innovation in archival services must heed the dynamic principle. The architecture must be dynamic to move quickly to changes and developments in government functions and information and communication technology, so swift, adaptable, and dynamic service development methods are needed. By encouraging the emergence of microservice architectures, the service-oriented architecture (SOA) technique is the basis for inventing a service-based computing paradigm [7]. In distinction to SOA, microservice architecture carries a straightforward service development technique that concentrates on one functionality to perform effectively to minimize the complexity of SOA [8]. Microservice facilitates the development of containerization that helps a lightweight approach [9], collaboration [10], and adaptability to rapid and continuous business transformations [11]. Moreover, it has distinct roles that can be used, enhanced, and independently tested [12]. Therefore, meeting dynamic business needs in line with the rapid growth of IT services in the archival system development can be realized with microservice architecture.

In addition to the integrated and dynamic principles, compliance is the third principle required in designing the architecture of the national archives service. The principle of compliance requires that the architecture be designed based on policies, laws, and regulations, as well as national and international standards regarding archives. Article 66 of the Law of the Republic of Indonesia Number 43 of 2009 contains regulations governing archives that ought to preserve archives for 25 years. Corresponding with the national regulations of archival storage, the open archival information system (OAIS) reference model is an international standard in ISO 14721:2012, which provide a systematic approach to preserving electronic archive. Tripathi [13] developed the preservation of digital records by packaging entities and metadata of digital records for reusability. Also, Rahmanto and Riasetiawan [14] develops an OAIS-based digital record repository system for data preservation strategies. Implementing OAIS as a digital preservation framework makes the compliance requirements achievable in designing the national archival platform system that aligns with corresponding regulations and standards.

Comprehensible is the last principle, which requires the architecture to be easy to understand and uncomplicated. The method used by [15] comments that the platform can integrate various complex service systems into one container that can be easily comprehended and utilized by other entities. Further, the service platform method proposed by [16] can involve several services that are integrated as an entirety. Hence, the concept of a service platform is required to design a national archival platform system that implements the comprehensible principle.

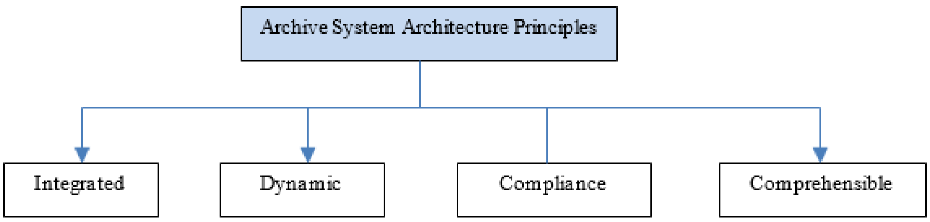

Figure 1. Archive system architecture principles

The research that supports integrated, dynamic, compliance, and comprehensible have drawbacks of not comprehensively fulfilling all principles. Building an integrated archive service system requires a combination of several methods and technologies. The application of the service platform method is expected to provide convenience for all ANRI stakeholders in meeting the needs of archival services. The platform design utilizes microservices in [17] as an architecture to increase flexibility and service availability. The methodology used in designing the archive management system platform is SCSE [6] to identify business service needs and IT services in creating service innovations by using the OAIS reference model as a service design reference. Thus, this research is intended to design a national archival platform system based on the combination of microservice-based platform design methods using SCSE complement with OAIS standard and archival SPBE principles. The organization of this paper includes research methodology in section 2, followed by the result and discussion of this study in section 3. Lastly, the conclusion is available in section 4.

2. METHOD

The development of a national archival system in this research employs a mixture of service computing system engineering, service platform, microservice architecture, and reference model from corresponding business methods described in Table 1. This research uses three stages: objective and requirements, modeling, and development.

Table 1. Mixture methods

SCSE	Service platform	Microservice modeling	Reference model
Objective and requirements	Domain analysis		OAIS reference model
Modeling	Platform architecture design	Microservice modeling process	Mapping
Development	Core assets implementation		

The objective and requirements stage in SCSE is comparable to the domain analysis on the engineering platform and the development stage in SCSE with core assets implementation on the engineering platform. However, SCSE provides more detailed activities, which become the foundation of mixed methodologies. The OAIS reference model methodology complements others to produce standard-compliant business processes. The modeling stage includes microservice modeling activities such as identifying microservice candidates and standard and derived features. In addition, to ensure that the resulting model complies with the standards, mapping activities are added to the OAIS reference model.

2.1. Objective and requirements stage

The objective and requirements stage identifies service strategies, objectives, needs, and innovations. The implementation of this stage must be determined by the strategy and business needs of the organization and improve the business services of the organization. This stage includes 3 phases: service strategy and objectives, service requirements, and service innovation. All phases, steps, and artifacts in the objective and requirements stage are shown in Figure 2. It shows the improvised SCSE artifacts utilizing OAIS as a reference model.

The service strategy and objectives phase determine the service strategy and objectives at ANRI, which contains the business process model and notation (BPMN) As-Is. In comparison, the service requirement analysis identifies the business needs relating to the archival management process. The reference model analysis process is needed to map service requirements with related service standards, which consist of existing business services and IT services [18].

The results of identifying business service needs, reference models, and IT services are used to develop service innovation. In this phase, a new business service model is proposed to produce a service innovation. The technology selection artifact is added as a set of technologies needed to improve the new model. The business service catalog artifact contains the list of business service innovations that align with the IT services innovations.

2.2. Modeling stage

The emphasis of the modeling stage is to design the model and architecture of the service system platform. Modeling possesses business services and IT services. IT services are software services that support the implementation of business services. This stage consists of the business service modeling, IT service modeling, and service design and architecture phases. All stages, phases, and artifacts in the modeling stage are shown in Figure 3.

Business service modeling helps identify business services' capabilities and explain in detail what services do and how they interact. In comparison, the IT service modeling aims to support the implementation of business services. In this phase, service specifications and service realization are modeled.

Activities in the service modeling use the service oriented architecture modeling language (SoaML). The service communication modeling is added because microservice architecture differs from SOA, which can communicate without enterprise service bus (ESB). The service architecture design is used as a baseline in the following process. Also, the design is evaluated to ensure the proposed architecture fulfills the service design requirements of coupling, cohesion, reusability, and complexity.

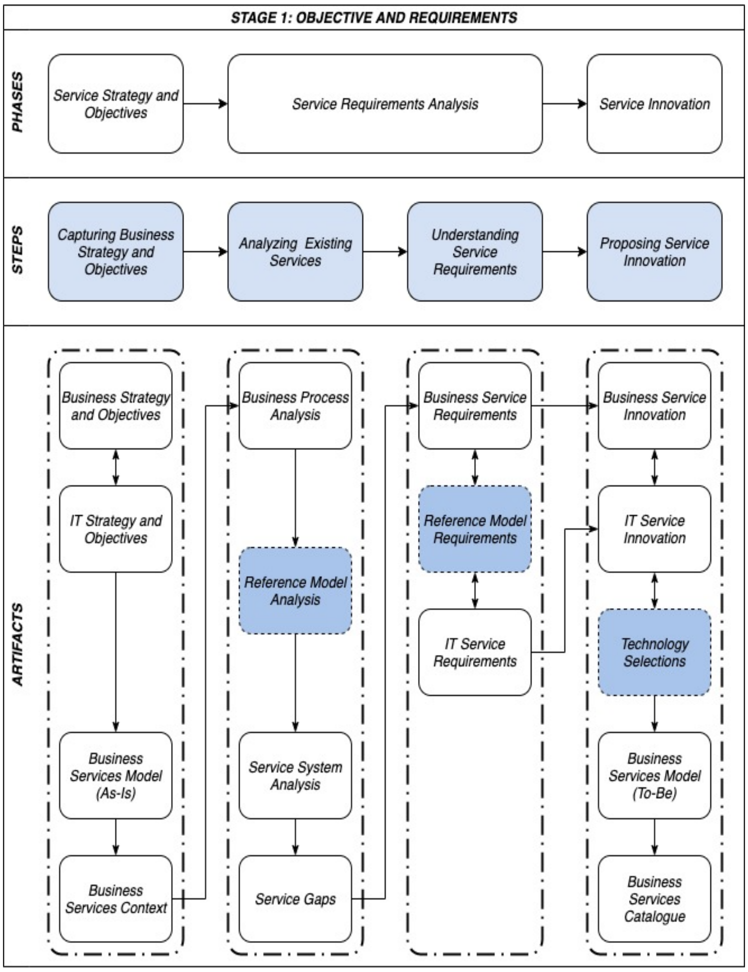

Figure 2. Objective and requirements stage

2.3. Development stage

The primary activity at this stage is the development of IT service systems in the form of implementing service designs and architectures that have been produced in the previous stage. This stage consists of a service development phase, service integration and testing, and service implementation. All stages, phases, and artifacts in the development stage are shown in Figure 4. The innovations are shown in the artifacts with the blue color of the implementation of the communication model, implementation of the data model, container implementation, UI integration, UI testing, and performance testing.

The addition of communication model artifacts, data models, and container implementations are added to accommodate the use of microservice architecture. The communication model comprises the architecture of intra-service and inter-service communication [19]. Data model activities include each service's data structure and data in aggregation services. Another new activity is container implementation which needed to compartmentalize each service domain. In order to ensure the service integration with the front-end system, UI integration, and testing are included. Furthermore, testing the entire system platform is carried out according to the designed service model to ensure that the system platform is functioning properly [20]. A service implementation plan is prepared to deploy the validated platform system into the production environment.

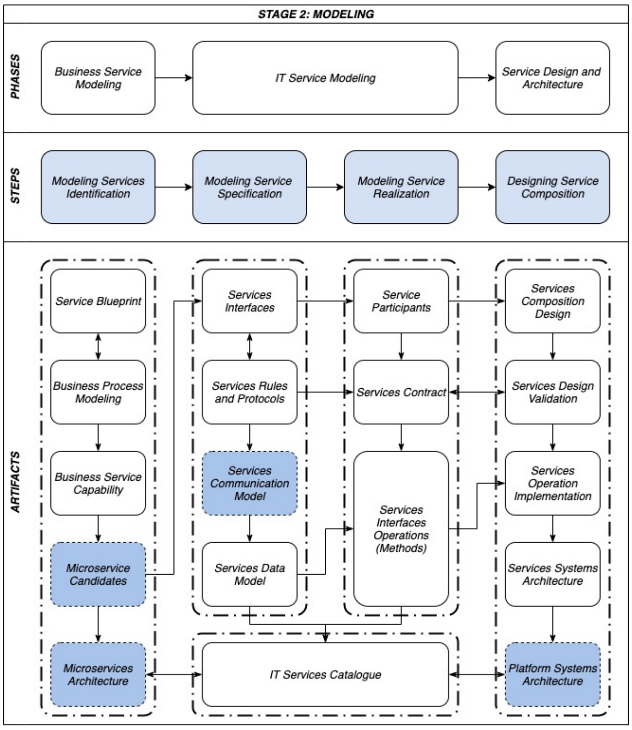

Figure 3. Modeling stage

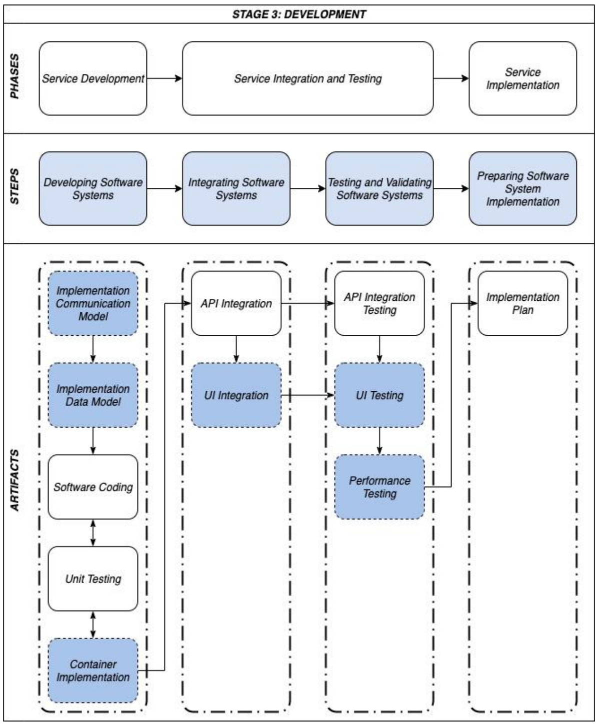

Figure 4. Development stage

2.4. Evaluation

Evaluation in this research consisted of the evaluation of design and performance. Design evaluation is helpful to ensure that the design is in accordance with service-based principles, while performance evaluation is needed to see the extent to which the level of availability of the system platform built can meet user needs. These two evaluations are an essential part of the development of this system platform.

2.4.1. Design evaluation
Service design evaluation includes measuring the value of the service design's coupling factor, cohesion factor, complexity, and reusability [21]. Evaluation observes interactions between services and operations within and with other services. Through the evaluation, it can be stated whether the proposed design is acceptable.

2.4.2. Performance evaluation
The purpose of performance evaluation is to measure the performance of the formed system platform. Dependability is a performance measurement method that shows that the system has a level of confidence in successfully serving user requests with an acceptable possibility of failure [22]. There are five tests of reliability, availability, integrity, safety, and maintainability on the dependability attribute. In this study, the availability test is used to measure the performance of the platform in accordance with the research objectives. In a service computing system, various possible events such as failure, attack, repair, or recovery cause various states or conditions that affect the system's ability to receive and provide services to users.

3. RESULTS AND DISCUSSION
The section consists of the research results of designing the national archival platform system using a microservice-based SCSE framework. The design follows the SCSE stages of objective and requirements, modeling, and development stages. Each stage is breakdown into several steps to achieve the proposed design.

3.1. Objective and requirements stage
The results of the objectives and requirements stages that have been carried out will be presented in this section. This stage consists of several steps: strategy goals, service context, identification, and analysis of the business, which resulted in service innovation. The service strategy and objective phase, the service requirements analysis phase, and the service innovation phase will display artifacts as the output of the research results.

3.1.1. Business strategy and goals
Business strategy and objectives must be aligned with the organization's vision and mission. The organization's vision and mission are guidelines for compiling various things such as goals, strategic objectives, strategies, and work programs. Based on the strategic plan document, ANRI has set the vision and mission for 2020 to 2024 as follows [3]. One of the objectives of ANRI's strategy to support the ANRI’s mission is to study and develop the archive system, which is ANRI's business strategy related to this research. Every activity in the organization should deliver significance for the organization in accomplishing its objectives. The value chain of the archival activities is described through a value chain diagram to determine the principal and supporting activities.

3.1.2. Business service context
Identification of the service scope is needed to describe the service in general. Context diagrams are formed to display the flow of information processed by a service to provide an overview of the system as a whole. Figure 5 shows the scope of the national archive management service at ANRI. The stakeholder map matrix shows the process in each corresponding parties.

3.1.3. Business process identification and analysis
The main activities in managing national archives have been previously identified through the value chain. Furthermore, business functions are broken down into more specific business processes. The following is the result of the identification of business functions and business processes related to the management of national archives described in Table 2.

3.1.4. OAIS reference model analysis
Based on the business process analysis above, digital archive preservation needs to be carried out to protect the value of digital archives so they remain authentic and can be accessed and reused by agencies and the public. The OAIS model as a reference model for digital archive preservation provides services for digital preservation needs to meet records management standard [23]. OAIS model involve three actors: creators, users, and management. The three actors are in accordance with the needs of ANRI's business processes described previously, which consist of archive users, ANRI and archival institutions, and archive creators. The OAIS model has six functional services involving the three actors, which are described in Table 3.

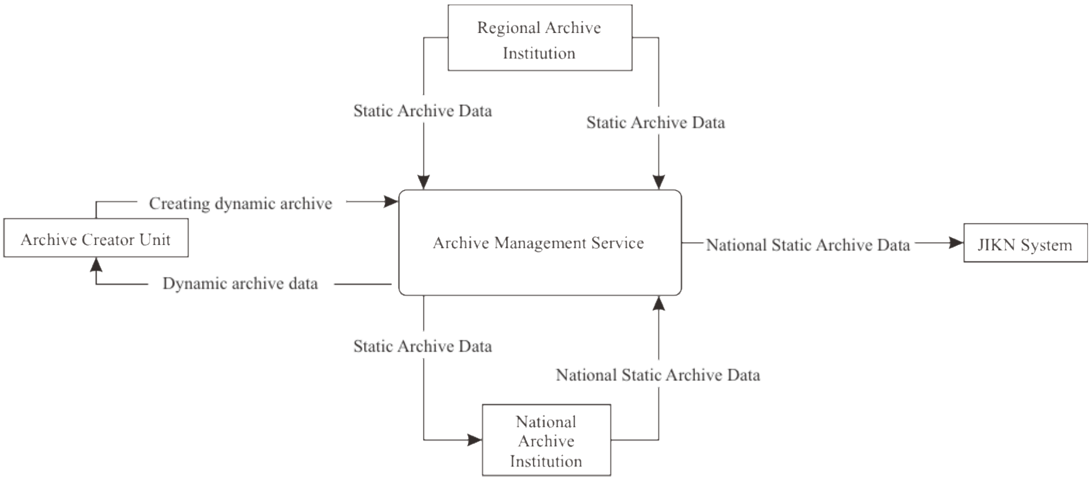

Figure 5. National archive context diagram

Table 2. Ongoing records management business functions and business processes

Business functions		Business processes (As-Is)	
BF1	Dynamic archive management	BP1	Archive creation and reception
		BP2	Archive usage
		BP3	Archive maintenance
		BP4	Archive shrinkage
BF2	Static archive management	BP5	Archive acquisition
		BP6	Archive processing
		BP7	Archive preservation
		BP8	Archive Access and Publication

Table 3. OAIS model functional services

No	OAIS Services	Description
SO1	Processing	A service for packaging digital archives that are stored with the addition of metadata information prepared for the convenience of archive storage and data management services
SO2	Archive storage	A service for storing digital archive documents that can be maintained, backed up, and error checking
SO3	Data management	A service for managing digital archive description information.
SO4	Administration	A service to monitor the digital archive process for compliance with standards and policies, which also provides archive reports
SO5	Preservation	A service consists of the archive preservation process, so it can be accessed and stored for a long time
SO6	Access	A service provides receiving and requesting access to digital archives

3.1.5. IT service innovations

IT services firmly support business services, so innovation in IT services becomes the enabler for business service innovation. There are 12 IT service innovations proposed in this paper. The identification of IT service innovations that support the management of national records is shown in Table 4.

Table 4. IT service innovation for national archive platform

No	IT Service Innovations	Description
TS1	User management	A service for managing users' data for authentication and authorization access
TS2	Archive management	A service for managing electronic archives
TS3	Agency management	A service for managing involved stakeholders
TS4	Digital certificate management	A service for managing users' digital certificate
TS5	Event management	A service for managing event
TS6	Acquisition	A service for acquiring dynamic archives from creators
TS7	Processing	A service for processing dynamic archive to ensure the archival's metadata standard
TS8	Preservation	A service providing integrity and periodic back up for archival data
TS9	Publication and Access	A service providing publication and access for static archives
TS10	Notification	A service providing notification features
TS11	Signing	A service for signing events and digital documents
TS12	Verification	A service providing verification for archival processes

3.2. Modeling stage

This section describes the modeling phase's results, including modeling business and IT services. This stage displays the results of the business service modeling, IT service modeling, and service design and architecture phases. The output of the research results in each phase are artifacts created using SoaML and service blueprints and BPMN in business service modeling.

3.2.1. Microservice platform

After obtaining a catalog of IT service innovations and mapping them into candidate microservices, then grouping these microservices into core and special services are shown in Figure 6. The unified records management platform has core services that special services can leverage. The core services include user management, archive management, agency management, digital certificate management, event management, notification, and signing. In comparison, the special services contain acquisition, processing, preservation, access, and verification.

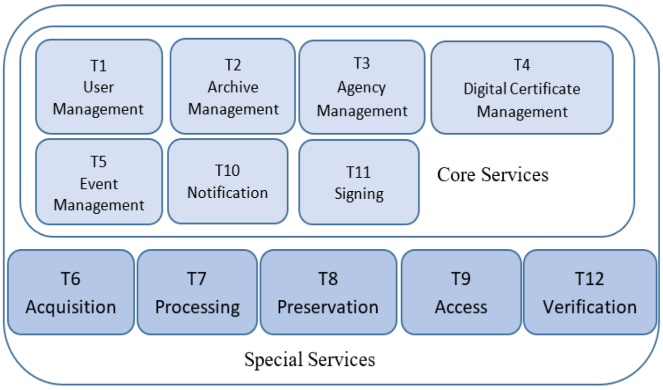

Figure 6. Microservice candidate grouping

3.2.2. Service design validation

At this stage, an evaluation of the service design will be carried out. The evaluation includes the suitability of the service with the four main principles of SOA design of coupling, cohesion, complexity, and reusability. The interaction of each service is also evaluated to measure each service's loose coupled.

a. Coupling value

The coupling parameter measures the level of dependency between services in a system. A good system has a low dependence between services, which is called loosely coupled. The desired value is close to 0. Based on the modeling that has been done, the following calculations are obtained. The coupling factor value obtained is 0.00282, indicating that the level of dependence between services is low. Therefore, the service design is loosely coupled.

$$CopF(p) = \frac{10}{60^2 - 60} = 0.00282$$

b. Cohesion value

The cohesion parameter is used to measure the level of component attachment. In this case, the operation in service and system. Two parameters show the cohesion value, cohesion metric (CM) to measure the cohesion value in service, and cohesion factor (CohF) to measure the cohesion value in the whole system. The proposed design has a cohesion value of more than 0.4, which means the interrelated functions are high cohesion.

$$CohF(s) = 0.457062$$

c. Complexity value

The complexity value parameter is used to assess the level of complexity of the interaction between services and operations in a service system. The higher the complexity value, the more complex the system's design. Thus, it is required to have a small complexity value. The proposed design has a low level of complexity value.

$$ComF(s) = \frac{0.0028}{0.457} = 0.0062$$

d. Reusability value

The reusability value parameter is used to assess a system's service usage level. The approach is to use a system's cohesion and coupling values. A good system has a high reusability value if the level of cohesion is high while the level of coupling is low.

$$ResF = \frac{48}{10} = 4.8$$

3.3. Development stage

System development based on the design carried out in the previous stage will be explained. The results of this stage include the service development phase, the service integration and testing phase, and the service implementation phase, which will display several artifacts as the output of the research results. Implementation of the system design into service-based applications is carried out in the service development phase. Development is carried out in the form of a prototype to determine the suitability between the design and the implementation. The implementation results include the communication model, data model, software coding, and unit test testing for each operation contained in the service. The service communication model is applied to communication between internal services and external services [24]. Internal service communication is carried out by implementing access control to register internal services to communicate between services. Laravel Passport creates an API gateway based on Oauth2 as a standard user authorization protocol and secure secret code using JSON web token (JWT) [25].

The service development utilizes PHP and Go programming languages. The PHP programming language is included in the interpreter category, while the Go programming language is included in the compiler category. The PHP programming language implements in most services due to its faster development, but for services with a high load, developed using Go which has better performance. Figure 7 shows the platform's use of programming languages and databases. As for service testing, Codeception is used to create test scenarios. The tests carried out include unit testing, functional testing, and integration testing. Each test is necessary to ensure the system is operating correctly.

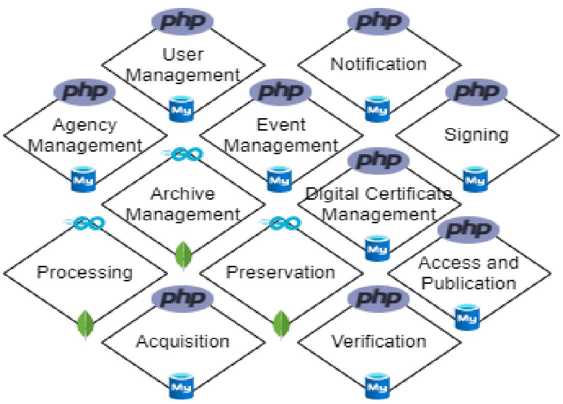

Figure 7. Service coding resources

4. CONCLUSION

This research proposed designing a national archival platform system using an SCSE microservice-based framework. The framework facilitates the SPBE principles in archives and the OAIS reference model. The utilization of microservice architecture promotes rapid development while the platform simplifies the integration into various systems. The service design validation was conducted to measure a system design's quality by performing coupling, cohesion, complexity, and reusability factor. The four factors are satisfied with the values of 0.00282, 0.457062, 0.0062, and 4.8 for coupling, cohesion, complexity, and reusability. Further, the measurement of the system's availability is employed to provide the specification of the platform's resources. Future works can focus on the integration of diverse archival metadata and archival security mechanisms.

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