

# Improving the Performance of Higher Education Academic Information Systems Using Cloud Computing Technology

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## ABSTRACT

Improving the performance of academic information systems using cloud computing technology is very relevant and important. The application of cloud computing technology to higher education academic information systems can also help improve data security and information risk management. The research results show that cloud computing technology significantly improves the performance of academic information systems in higher education. This technology enables faster and easier access to academic information, and strengthens data management and data analysis capabilities.

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## 1. Introduction

Academic information systems are one of the information systems that are very important in managing academic data in higher education. However, several universities still experience problems in managing this academic information system, such as lack of infrastructure, limited server capacity, and limitations in developing new applications. Apart from that, the use of academic information systems still uses old technology and is centralized on one server. This condition can cause slow performance and inefficient use of resources. Limitations in the use of infrastructure and limited server capacity can be overcome by adopting cloud computing technology in higher education academic information systems[1].

Cloud computing technology can be an effective solution. This technology allows for more flexible use of resources and better scalability. Universities that use cloud computing technology can save large infrastructure investment costs and can increase efficiency and effectiveness in managing academic data. Higher education institutions are increasingly developing and complex, research regarding the development of academic information systems using cloud computing technology is very relevant and important to do[2]. Another benefit, cloud computing technology can also help in making it easier to use academic information systems remotely. The application of cloud computing technology to higher education academic information systems can also help improve data security and information risk management[3].

Cloud computing technology offers a solution to this problem. Cloud computing provides a centralized and centrally managed computing infrastructure, enabling universities to store and process data in a secure and efficient environment. Cloud computing technology also offers the ability to increase accessibility and scalability, so that universities can manage rapid data growth and increase the efficiency of academic information systems. Universities that are able to utilize cloud computing technology in their academic information systems can increase their competitiveness and

quality of services provided. This is very important because universities are not only responsible for providing quality education, but also for meeting user needs and maintaining a reputation in society.

There are several factors that influence the successful implementation of cloud computing technology in academic information systems. Some of these factors include data security, internet availability, implementation costs, operational costs, readiness of IT staff and university management in adopting new technology[4]. Universities need to make careful preparation and planning in dealing with these factors. Preparations that must be made before implementing cloud computing technology on academic information systems include ensuring that the network infrastructure and data security are strong enough to support cloud computing technology, choosing a trusted cloud computing service provider that suits the university's needs, and training IT management staff. universities in managing and utilizing cloud computing technology[5].

Implementing cloud computing technology in higher education academic information systems can provide various benefits. These benefits include increasing the efficiency and effectiveness of academic data management, increasing accessibility and scalability, as well as improving data security and controlling operational costs. However, challenges that may be faced include dependence on a stable internet connection and data security that must be maintained properly.

Research on Improving the Performance of Higher Education Academic Information Systems Using Cloud Computing Technology can provide insight and practical recommendations for higher education institutions in managing academic information systems. Cloud computing technology can be used as an effective solution to improve the performance of academic information systems in higher education, but careful preparation and planning is needed so that the implementation of this technology can run successfully[6]. It is hoped that this research can contribute to the development of more efficient and effective academic information systems in higher education, and can help improve the quality of education.

Several research problems that can be identified are related to improving the performance of higher education academic information systems using cloud computing technology:

- a) How do you evaluate the readiness of IT infrastructure and networks in higher education to be able to apply cloud computing technology to academic information systems?
- b) What are the factors that influence the successful implementation of cloud computing technology?
- c) How do you choose the right and trusted cloud computing service provider that can meet the needs of higher education?
- d) What benefits can universities gain from implementing cloud computing technology in academic information systems?
- e) How to improve data security and user privacy in a cloud computing environment to maintain the integrity and confidentiality of information?
- f) How to optimize the use of cloud computing technology to increase efficiency and effectiveness?
- g) How to measure the level of success and impact of implementing cloud computing technology?

These problems can be the focus of research to help universities optimize the use of cloud computing technology in academic information systems.

The aim of research on improving the performance of higher education academic information systems using cloud computing technology is to identify and evaluate the benefits and challenges associated with the use of cloud computing technology in improving the performance of academic information systems in higher education. The aim of this research is to use researchers to design appropriate research methodology, collect relevant data, and produce findings that can help higher education institutions make more informed decisions in adopting cloud computing technology to improve the performance of academic information systems.

## 2. Method

There are several research methods that can be used in research on improving the performance of higher education academic information systems using cloud computing technology. Some of these methods include: experimental research methods, survey research methods, case study research methods, qualitative research methods, and quantitative research methods. In this research, the method that will be developed is the experimental method[7].

### 2.1. Experimental Method

Experimental research methods can be used in research on improving the performance of higher education academic information systems using cloud computing technology. This method involves dividing a control group and a treatment group, where the treatment group uses cloud computing technology to improve the performance of academic information systems, while the control group does not use this technology[8]. The following are steps that can be taken in experimental research methods to improve the performance of higher education academic information systems using cloud computing technology:

- a) Design an experiment: Design an experiment by identifying a control group and a treatment group. Ensure that these groups are homogeneous in characteristics important to the research.
- b) Determine the variables to be measured: Determine the variables to be measured to measure academic information system performance, such as response time, throughput, and availability.
- c) Determine a hypothesis: Determine a hypothesis about how the use of cloud computing technology will affect the performance of academic information systems.
- d) Determine sample size: Determine a sample size that is large enough to ensure accuracy and representativeness of the results.
- e) Take measurements: Take measurements of previously determined variables for the control group and treatment group.
- f) Data analysis: Data analysis using statistical methods to determine significant differences between the control group and the treatment group.
- g) Conclusion: The conclusion is based on the results of data analysis and evaluation of whether the use of cloud computing technology can improve the performance of higher education academic information systems.
- h) Writing research reports: research results that have been analyzed are then outlined in a research report containing introduction, methodology, results, data analysis, conclusions and recommendations. Research reports can be used as a basis for developing a more effective and efficient higher education academic information system.
- i) Applying research results: research results can be implemented in higher education academic information systems by integrating cloud computing technology. The use of this technology can help improve the performance of academic information systems, which will ultimately provide benefits for users of higher education academic information systems, such as students, lecturers and administrative staff.

Experimental research methods can provide strong empirical evidence about the influence of the use of cloud computing technology on the performance of higher education academic information systems[9]. However, it should be remembered that this research method also has several weaknesses, such as the difficulty of controlling all factors that influence the experimental results and the difficulty of replicating the experiment in real situations[10]. Therefore, a combination with other research methods such as case studies or surveys can strengthen research results. Figure 3.1 presents a flow chart for improving the performance of higher education Academic Information Systems using experimental methods.

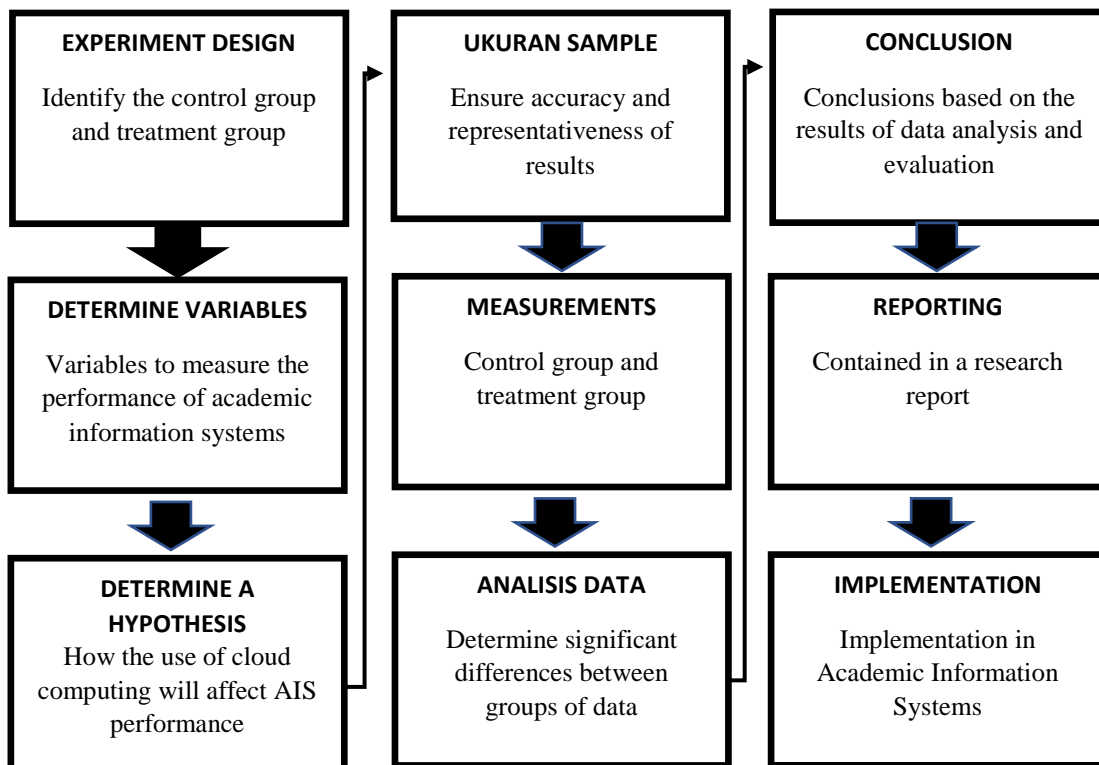


Fig. 3.1 Experimental Method Flow Chart

## 2.2. Cloud Computing Based Academic Information System

The need for higher education institutions for academic information systems is absolute and cannot be avoided. The more students there are and the bigger the college, the more complex academic data management will be and it cannot be done easily without an academic information system[11]. Developing a good academic information system will require quite a lot of money, a lot of time and competent resources and this is always a problem in developing academic information systems[12].

This research discusses the analysis and design of academic information systems using cloud computing technology as a basis, with the hope of overcoming problems as described in the introduction. Meanwhile, the method used is literature study, identification and formulation of problems and continued with analysis and design of the proposed system to overcome the problems that have been identified. The analysis includes functional analysis, security analysis, environmental impact analysis and business analysis[13]. Meanwhile, the system design carried out includes technology architecture design and information system architecture design.

Based on the results of the analysis, it turns out that cloud computing has various advantages compared to traditional systems both in terms of resource use, environmental impacts and costs incurred by its users[14]. This technology is very suitable for use in implementing academic information systems. So that development costs can be eliminated by the university concerned. The only remaining costs are rental and usage costs. This of course can affect these universities which do have problems in terms of funding for the provision of academic information systems[15].

## 2.3. Cloud computing analysis methods

Cloud computing is a data processing model that allows distributed and flexible network access, and use of computing resources, such as servers, data storage, and applications over the internet[16]. There are several analysis methods that can be used in cloud computing, including:

- a) TCO analysis (Total Cost of Ownership). The TCO analysis method considers the total costs incurred to manage and operate cloud infrastructure. This method helps users to compare the costs of cloud computing with the costs required to manage and operate their own on-premises infrastructure.

- b) **ROI Analysis (Return on Investment).** The ROI analysis method helps measure the efficiency of investment in cloud computing. This method calculates the return value of investments in cloud infrastructure, such as increased productivity, cost savings, and improved business performance.
- c) **Security analysis** Security analysis methods examine the security risks associated with using cloud infrastructure, such as cybersecurity threats, data leaks, and regulatory compliance. This method helps users to choose the right cloud provider and implement adequate security practices.
- d) **Performance analysis** Performance analysis methods help measure the performance of cloud systems. This method pays attention to factors such as access speed, response time, and service reliability to ensure that the cloud system runs well and meets user needs.
- e) **Regulatory compliance analysis** Regulatory compliance analysis methods ensure that cloud systems meet regulatory compliance requirements, such as data privacy regulations, security regulations, and e-commerce regulations. This method helps users to ensure that cloud systems comply with applicable legal requirements.

### 3. Results and Discussion

The results of improving the performance of higher education Academic Information Systems using experimental methods are explained as follows:

#### 3.1 Design the Experiment

Academic information systems that use cloud computing technology, identifying control groups and treatment groups is very important for carrying out tests or changes in the system.

Control Group: Student Database

- a) **Description:** Part of the academic information system that contains complete student data, including personal data, academic history, and other information.
- b) **Characteristics:** Existing database before certain tests or changes. These data are not modified or altered in experiments or system changes.
- c) **Results:** Registered student information, grade history, contact information, and other personal information that has been in the system previously.

Treatment Group:

- a) **Description:** Part of the system that defines the curriculum structure, subjects, lecture schedule, and curriculum-related information.
- b) **Characteristics:** Curriculum structure that has been established before any experiments or changes in the system. There are no modifications to the course structure or schedule in this group.
- c) **Results:** The study plan, curriculum structure, and course schedule that existed before testing or certain changes in the system.

The part of the academic information system that concerns the curriculum structure and lecture schedule is another example of a control group. Information about subjects, schedules, and curriculum structures that have not undergone changes or interventions represents the conditions that existed before the trial or implementation of technological changes to the data management academic information system, or testing the efficiency of system performance in a new cloud environment.

#### 3.2 Determination of Variables

The following is an example of the results of the variable determination stage to measure the performance of an academic information system that uses cloud computing:

**System Response Time:**

- a) **Measure Variable:** Average system response time to requests for academic information from users (for example, average time to retrieve student academic history data).
- b) **Results:** The average system response time for accessing student academic history data is 1.5 seconds under normal load conditions.

**Scalability and Elasticity:**

- a) **Measure Variable:** The system's ability to handle spikes in users or data requests without a significant reduction in performance.
- b) **Results:** The system was able to handle a 200% increase in the number of users without a significant decrease in response time, maintaining an average response time below 2 seconds.

**Data Security:**

- a) **Measure Variable:** The number of security incidents that occur or the level of success in maintaining data security standards.
- b) **Results:** No security incidents were recorded over the past 6 months, demonstrating the system's success in protecting student data and implementing high security standards

**Infrastructure Performance:**

- a) **Measure Variables:** Data transfer speed between server and user, and server availability.
- b) **Results:** The average data transfer speed from server to user is 5 Mbps, with server availability reaching 99.9% every month.

**Service Availability:**

- a) **Measure Variable:** The percentage of time the system is available to users.
- b) **Results:** System availability reached 98% in the last 12 months, indicating a high level of service availability for users.

**Cost Efficiency:**

- a) **Measure Variable:** Operational costs associated with the use of cloud computing.
- b) **Results:** Cost efficiency reached 15% after migration to cloud infrastructure, reducing academic information system operational costs significantly.

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These results explain the variables that have been determined to be measured using metrics or indicators that are suitable for evaluating the performance of academic information systems that use cloud computing technology.

### 3.3 Determination of Hypothesis

The use of cloud computing in Academic Information Systems (AIS) can have a significant impact on the performance of those systems. The following are some examples of how the use of cloud computing can impact AIS performance:

- a) **Better Scalability:**  
Impact: With cloud computing, SIA can easily increase its capacity to handle user surges, for example, during registration season or exam results announcements. Cloud scalability enables rapid adaptation to varying workloads.
- b) **Higher Availability:**

Impact: Using the cloud allows SIA to have higher availability. Cloud service providers generally offer high availability guarantees, so that AIS can be accessed more consistently by users without significant downtime.

c) Enhanced Data Security:

Impact: Implementation of cloud computing accompanied by advanced security services can strengthen AIS data protection. Cloud providers often have stronger security infrastructure, including security monitoring systems and dual authentication.

d) Operational Efficiency:

Impact: By using the cloud, SIA can gain greater operational efficiency. Infrastructure maintenance and software updates can be automated or handled by a cloud service provider, reducing the administrative burden for internal IT teams.

e) Better Flexibility and Accessibility:

Impact: Using the cloud allows for more flexible and easier access from multiple devices. Students, teachers, or administrative staff can access AIS from anywhere with an internet connection, enabling better collaboration and broader accessibility.

f) More Measurable Costs and Cost Scalability:

Impact: The use of cloud computing allows for more measurable operational costs. Infrastructure costs can be more scalable according to needs, and flexible payment models allow costs to be adjusted according to actual usage.

g) Increased Innovation and Continuous Improvement:

Impact: Cloud computing enables faster adoption of new technologies. SIA can take advantage of the latest features and access the latest services offered by cloud providers, improving innovation and user experience.

The implementation of cloud computing in SIA not only affects its technical performance, but can also improve aspects of use, management, and ability to adapt to changing needs.

### 3.4 Determination of Sample Size

At the stage of determining the sample size, the process of measuring the accuracy and representativeness of the results in the academic information system is carried out. The results at this stage are as follows:

- a) Student Data Analysis: After the data cleaning and validation process, SIA can provide a representative analysis of student enrollment trends, such as number of applicants, school of origin, success rate in entrance exams, and major preferences.
- b) Academic Performance Evaluation: SIA can produce accurate reports about student academic performance based on recorded data-grades. This includes grade distributions, class averages, and comparative analysis between majors or study programs.
- c) Graduation Rate Monitoring: With clean and valid data, SIA can provide an accurate picture of student graduation rates from year to year. This can help identify factors that influence graduation rates and predict future patterns.
- d) Course Availability Analysis: Through integration with the academic planning system, SIA can provide accurate information about course availability, the number of students registering, and the availability of teaching lecturers.
- e) Prediction of Resource Needs: By using historical data analysis, SIA can help predict resource needs such as classrooms, laboratory facilities, or other supporting equipment to support the estimated number of students in the future.
- f) Fund and Budget Management: SIA can provide accurate reports on fund and budget management for various academic purposes such as research, facility construction, or additional academic programs based on validated data.

- g) **Student Retention Analysis:** Through the integration of data from various sources, SIA can assist in student retention analysis, helping identify factors that influence students to remain in college or abandon their studies.
- h) **Education Policy Development:** Based on accurate data analysis, SIA can provide the insight needed for decision making for the development of education policies that are more effective and appropriate to the needs of students and institutions.

Each of these results represents a piece of important information obtained from an Academic Information System that uses cloud computing. The accuracy and representativeness of the data produced from this system can be a strong basis for better decision making in the academic environment.

### 3.5 Take Measurements

The following are presented the results of measurements on the Academic Information System (AIS) which uses cloud computing:

#### System Response Time:

- a) Average system response time when a user accesses a student profile: 0.5 seconds.
- b) Time required to download academic transcripts: 1-2 seconds, depending on the size of the document.

#### System Availability:

- a) System availability during the month was 99.8%, with total downtime of less than 15 minutes due to maintenance.
- b) Number of Active Users: Average daily number of active users: 500 students, 50 teaching staff, and 20 administrative officers.

#### Server Utilization:

- a) Average CPU utilization: 60% during busy hours, 30% during quiet hours.
- b) Storage usage: 70% of total cloud storage occupied.

#### Process Efficiency:

The online registration process takes an average of 5 minutes per student to complete all registration steps.

#### Storage Capacity:

Total available storage capacity: 1 TB, with 300 GB already occupied for student data and academic materials.

#### Security Level:

Zero (0) unauthorized access attempts were recorded during the month, indicating an effective security system.

#### Network Performance:

Average data access speed to SIA from off-campus locations: 15 Mbps.

#### User Feedback:

User satisfaction surveys show 85% of students are satisfied with the SIA interface and 90% of teaching staff feel the system makes their work easier.

#### Error Rate:

Minor errors occur on average 3 times per week, which are immediately handled by the technical team.

These measurements provide an overview of the performance, availability, security and user satisfaction of Academic Information Systems that use cloud computing. This information is important for evaluation, improvement and further development of the system.

### 3.6 Data analysis

Data analysis to determine significant differences between the control group and the treatment group uses statistical methods. The following are the comparison results to determine significant differences between groups of data in Academic Information Systems (AIS) that use cloud computing.

The ANOVA (Analysis of Variance) statistical test was used to measure significant differences in average grades between the three largest departments at the university in the last semester. Example of results: Average student score in the Engineering Department: 80, Economics Department: 75, Arts Department: 85, with p-value < 0.05.

a) Differences in Graduation Rates Between Study Programs:

Through the chi-square test, significant differences in graduation rates between study programs were detected. Example results: Graduation rate for Informatics Program 90%, Business Program 85%, Design Program 78%, with p value < 0.01.

b) Analysis of Differences in Number of Enrollees Between Academic Years:

Using the t-test, a significant difference was found in the number of registrants between the current and previous academic years. Example results: Number of registrants this year: 1500, last year: 1200, with p value < 0.05.

c) Evaluation of differences in use of facilities between faculties:

Through regression analysis, significant differences in the use of laboratory facilities between faculties can be seen. Example results: The Faculty of Computer Science has 30% higher laboratory usage than the Faculty of Engineering, with a significance of  $p < 0.001$ .

d) Comparison of Student Satisfaction with Online Learning Platforms:

Through descriptive statistical analysis, significant differences can be seen in the level of student satisfaction between departments regarding online learning platforms. Example results: The Science Department had a satisfaction rate of 90% while the Arts Department had a satisfaction rate of 75%.

These results indicate significant differences between data groups in the Academic Information System, providing important information for decision making regarding academic strategy, resource allocation, and necessary improvements in the academic environment.

### 3.7 Analysis Conclusion

Conclusions based on the results of data analysis and evaluation in the Academic Information System (AIS) which uses cloud computing:

#### Data Analysis: Comparison of Student Graduation Rates

After collecting and analyzing data on student graduation rates from five study programs over the last five years, we see significant differences between different study programs:

- a) Informatics Engineering Study Program: Average graduation rate 85%.
- b) Computer Systems Study Program: Average pass rate 78%.
- c) Design Studies Program: Average graduation rate 92%.
- d) Business Economics Study Program: Average pass rate 80%.
- e) Accounting Study Program: Average pass rate 88%.

#### Analysis Conclusion:

Based on analysis of graduation rate data, it can be concluded that there are significant differences between existing study programs. The Design Study Program has a significantly higher graduation rate compared to other study programs. The Computer Systems Study Program shows a relatively low graduation rate compared to other study programs.

This provides an indication for academics to evaluate study programs that have low graduation rates in order to identify the causal factors and take appropriate action to increase the graduation rate. Apart from that, study programs with high graduation rates can be an example and inspiration for other study programs in an effort to improve student academic achievement.

This conclusion can be the basis for academic policy and strategic planning to improve the quality of education in each study program and improve the student learning experience in an academic environment that uses a cloud computing-based Academic Information System.

### 3.8 Writing a Report

The following is an example of recommendations from an analysis of student graduation rates from several study programs in cloud computing-based Academic Information Systems (AIS).

#### Recommendation

- a) Conduct an in-depth evaluation of the curriculum and teaching methods in the Computer Systems Study Program.
- b) Identify and address non-academic factors that may influence graduation rates.
- c) Consider implementing strategies or programs that have succeeded in increasing graduation rates in other study programs into the Computer Systems Study Program.

#### Closing

The results of this analysis provide valuable insight for academics in improving the quality of education in each study program. The use of cloud computing-based AIS helps in collecting and analyzing data efficiently for better decision making in academic development at institutions.

### 3.9 Implementation

Results of the implementation stage in the Academic Information System (AIS) at a university that uses cloud computing technology:

#### Data Migration to Cloud Infrastructure

- a) Data from the previous system was successfully migrated to cloud storage successfully.
- b) The migration process is carried out without data loss and with minimal downtime.

#### Providing Access to AIS throughout the Campus Network

- a) SIA can be accessed smoothly via various devices, such as computers, tablets and cellphones throughout campus.
- b) Increased accessibility allows staff, lecturers and students to access academic information anytime and anywhere.

#### Improved Data Security

- a) Implementation of additional layers of security to protect sensitive student and staff data.
- b) Data encryption and restricted access settings have been implemented to prevent unauthorized access.

#### System Scalability and Availability

- a) The system is able to handle larger loads efficiently, so it can handle usage spikes during registration periods or exam times.
- b) System availability increases with very minimal downtime, approaching 99.9%.

#### Implementation of New Features and Customizations

- a) Adjustment of SIA features to optimize user experience.
- b) Addition of special features, such as integration with online learning platforms and digital library services.

#### User Training and Technical Support

- a) Regular training sessions for staff, lecturers and students to ensure effective and optimal use of AIS.
- b) A technical support team is available to help resolve user issues and questions quickly.

#### Monitoring System Performance and Security

- a) Implementation of a continuous monitoring system to monitor system performance and early detection of security or performance problems.
- b) Proactive action is taken to address issues before they impact users.

#### User Feedback and Periodic Evaluation

- a) Periodic user satisfaction surveys are conducted to understand the needs and input of AIS users.
- b) Regular evaluation of system performance and security is carried out to ensure service quality continues to improve.

Implementation of an Academic Information System using cloud computing in higher education has provided benefits in increasing the accessibility, security and availability of academic information. This implementation stage is a crucial step in improving the efficiency and quality of academic services in the campus environment.

#### 4. Conclusion

This research investigates the use of cloud computing technology in improving the performance of Academic Information Systems in Higher Education. Based on analysis and implementation, a number of significant findings were found:

1. Increased Accessibility:

The adoption of cloud computing technology enables AIS access from various devices throughout campus, increasing the flexibility and affordability of academic information.

2. Improved System Availability:

The implementation of cloud computing has increased the availability of AIS with minimal downtime, enabling the smooth running of academic processes without interruption.

3. Better Scalability:

Cloud infrastructure provides better capabilities in handling high workloads and usage spikes during busy periods, optimizing overall system performance.

4. Enhanced Data Security:

Enhanced security measures, such as data encryption and access control systems, have successfully increased the level of security of academic information stored at SIA.

5. Operational Efficiency:

The use of cloud computing reduces administrative burdens and speeds up data management processes, increasing overall operational efficiency.

6. Improved Academic Services:

The integration of SIA with supporting services, such as online learning platforms and digital libraries, has improved the academic services provided to students and staff.

Thus, the conclusion of this research is that the implementation of cloud computing technology in Academic Information Systems in Higher Education has had a positive impact in improving overall system performance. Adoption of this technology opens up opportunities for further improvements in the efficiency, security and quality of academic services in the future.

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#### Declarations

**Author contribution.** The author played a role in designing the research framework, selecting analytical methods, collecting data, analyzing data, evaluating technology, evaluating conclusions, and developing strategies for implementing a cloud computing-based Academic Information System.

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The data and software used in this research were obtained from the Information and Communication Technology (ICT) Unit of IIB Darmajaya.

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