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Integration of Zero Trust Architecture Model in Cloud-Based Academic Information System Design

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Abstract

This study investigates the integration of Zero Trust Architecture (ZTA) in cloud-based academic information systems to enhance data security within educational institutions. Utilizing a qualitative case study approach, data were collected through in-depth interviews and system observations at three universities. Findings reveal that ZTA strengthens access control and mitigates data leakage risks, although challenges remain in user adaptation to strict authentication protocols. This study highlights the need for user-focused implementation strategies, including training and system design that balance security and usability. The results show that ZTA's implementation has improved access control and reduced the risk of data leakage, but the main challenge is the user's adaptation to more stringent authentication procedures. Although data security is improved, user convenience is slightly affected by the more complicated verification process. This study suggests the need for more intensive training and socialization to improve user understanding of ZTA, as well as the development of systems that balance security and convenience. These findings are expected to provide guidance for educational institutions in adopting ZTA to improve the security of cloud-based academic information systems.

Keywords: zero trust architecture, academic information systems, cloud security, multi-factor authentication, cloud-based education, access control, user adaptation

A. Introduction

In the ever-evolving digital era, technological transformation has had a major impact on the way educational institutions manage and protect academic data. Cloud-based information systems are now the go-to choice for many educational institutions. However, threats to sensitive data are increasing alongside reliance on cloud systems. According to Forbes (2021), more than 60% of organizations have experienced cloud-related data breaches. Moreover, the COVID-19 pandemic accelerated cloud adoption without proportionate investment in security (Kim & Solomon, 2022).

Many Indonesian universities continue to rely on perimeter-based security models, which are less effective against modern threats. ZTA offers a security paradigm that assumes every access request is a potential threat. Previous studies (Bertino et al., 2020; Al-Ahmad & Al-Fagih, 2021) have highlighted ZTA's potential in securing cloud environments, but its application in academia, particularly in Southeast Asia, remains underexplored. This study holds relevance in addressing this gap.

In the education sector, especially in Indonesia, the application of cloud-based academic information systems is increasingly popular because of its efficiency in managing data on a large scale. However, many of these systems still rely on traditional security models that are not effective enough to deal with increasingly complex threats. According to the Indonesia Cyber Security Forum (2022), many universities in Indonesia still use a perimeter-based security approach, which assumes that threats only come from outside the system. This approach has proven inadequate in dealing with internal and external threats, such as data leaks due to human error or cyberattacks. Therefore, a more sophisticated and comprehensive solution is needed to improve data security in cloud-based academic information systems.

Several previous studies have examined the application of Zero Trust Architecture (ZTA) to cloud-based systems. Bertino et al. (2020) explain how ZTA can improve security by minimizing the risks stemming from internal and external data leaks through the implementation of stricter access controls and stricter user identity verification. In addition, Chung et al. (2021) in their research stated that ZTA allows for more granular control over users and devices accessing cloud data, thereby reducing potential threats to data integrity. However, although ZTA has been applied in various industrial sectors, there has not been much research that addresses its application in the context of cloud-based academic information systems, especially in developing countries such as Indonesia.

this study holds relevance in addressing the gap because with the rapid development of cloud technology in the education sector, there is an urgent need to improve the security layer of academic information systems so that student and lecturer data can be properly protected. Implementing Zero Trust Architecture (ZTA) in cloud-based systems can be an effective solution to address these challenges. With ZTA, the system can assume that any attempt at access is a potential threat, so security controls are carried out more strictly and thoroughly. In addition, this research is relevant because although there is a lot of research that discusses ZTA in an industrial context, its application in cloud-based academic information systems is still rarely discussed in depth.

The uniqueness of this research lies in the focus on the implementation of Zero Trust Architecture in cloud-based academic

information systems, especially in educational institutions. Most of the existing research discusses ZTA in the context of business or government organizations, while very few discuss the application of ZTA in the education sector. The study fills that gap by offering a specific and integrated ZTA model for protecting academic data, which is very different from traditional approaches that rely more often on perimeter security.

The main objective of this study is to analyze how the Zero Trust Architecture model can be integrated in the design of cloud-based academic information systems to improve its security layer. This study aims to explore the relevant components of ZTA in the context of education and develop an application model that can be used by educational institutions to reduce potential threats to sensitive academic data.

This research is expected to make a major contribution to the development of a more secure cloud-based academic information system in educational institutions. Practically, the results of this study can help information system managers in educational institutions to design and implement a stronger security architecture, as well as increase awareness of the importance of academic data security. Theoretically, this study will add to the literature on the application of ZTA in the context of education, which can be a reference for further research in the future.

The implications of this research are very broad, both for information system managers in educational institutions and for policy makers. The implementation of ZTA is expected to increase user trust in cloud-based academic information systems, thereby increasing the adoption of this technology among educational institutions. In addition, this research can also provide guidance for policymakers in setting security standards for cloud-based academic information systems at the national or international level.

B. Research Method

Types of Research

This study uses **a qualitative method**, with a **descriptive** approach to examine the application of Zero Trust Architecture (ZTA) in the design of cloud-based academic information systems. Qualitative research was chosen because this study aims to understand in depth how the ZTA model can be integrated into academic information systems in educational institutions, as well as to explore the benefits and challenges faced during the application of this model. The qualitative approach makes it possible to gain a more comprehensive insight into the technical and operational aspects of ZTA implementation. A qualitative approach was selected to capture nuanced insights into organizational behavior, user adaptation, and security implementation strategies that quantitative methods may overlook (Creswell & Poth, 2018). Thematic analysis was applied to interpret interview transcripts, observation notes, and document reviews. NVivo

software was utilized to code data and identify recurring themes related to ZTA benefits and user experience (Nowell et al., 2017).

Research Design

The research design used in this study is a case study. The case study was chosen because this study aims to explore the application of Zero Trust Architecture in cloud-based academic information systems in specific educational institutions. The case study approach allows researchers to identify the problems faced, the solutions implemented, as well as the outcomes and challenges that arise from the integration of ZTA. This research will be conducted by conducting direct observations on systems that have implemented ZTA and analyzing its impact on data security.

Location and Research Subject

This research will be carried out in **several higher education institutions** that have implemented cloud-based academic information systems. The research location includes universities that have high needs in the management of student and lecturer data. The research subjects involve **IT teams**, **system administrators**, and **system users (students and lecturers)** who are directly involved in the use and management of cloud-based academic information systems. The selection of these educational institutions is based on their readiness to adopt new technologies and their relevance in the context of higher education.

Research Instruments

The main instruments used in this study were **in-depth interviews**, **direct observation**, and **document analysis**.

1. **In-Depth Interviews**: Interviews will be conducted with system managers (IT team and administrators), system users (lecturers and students), and parties involved in decision-making related to ZTA implementation. This interview aims to gain insights related to their experiences and views on the implementation of ZTA, as well as the challenges faced in its implementation.
2. **Direct Observation**: The researcher will observe the cloud-based academic information system implemented in the research institution to see how ZTA functions in controlling access and protecting data.
3. **Document Analysis**: Documents related to the security system, access policies, and operational procedures related to ZTA will be analyzed to understand the framework implemented in the system.

Data Collection Techniques

The data collection techniques in this study include the following steps:

1. **Interviews**: Researchers will conduct semi-structured interviews with relevant parties at each educational institution to explore their experiences regarding ZTA's integration in cloud-based academic information systems. This interview will last 30-45 minutes, depending on the depth of information obtained.

2. **System Observation**: The researcher will conduct direct observation of the implementation of ZTA in a cloud-based academic information system applied in the institution that is the subject of the research. This observation will include observations of authentication procedures, access control, and the use of security tools and procedures related to ZTA.

Security Policy Documentation and Analysis: The researcher will collect and analyze existing security policy documents, including guidelines related to the use of academic information systems, as well as the control mechanisms applied to cloud systems

C. Result and Discussion

General Description of Respondents

This study involved 30 respondents consisting of three groups: the IT team (10 people), system administrators (10 people), and system users (10 people, consisting of lecturers and students). Respondents were selected from three universities that have implemented a cloud-based academic information system with Zero Trust Architecture (ZTA). Most of the respondents were from institutions located in large cities, with 60% of respondents being IT staff and 40% being system users.

Respondents consisted of:

- **IT Team**: Have more than 3 years of experience in managing cloud-based systems.
- **System Administrator**: Plays a role in the management and supervision of access to academic data.
- **System Users (Lecturers and Students):** Use the system for academic and administrative purposes.

Key Findings from the Interview with Management

From interviews with the management (IT team and system administrator), some of the key findings are:

1. **Successful ZTA Implementation**: The majority of respondents from IT teams and system administrators revealed that ZTA implementation successfully improved access control to academic information systems. One IT manager said, "Zero Trust allows us to verify the identity of every user every time they access sensitive data, which previously relied only on perimeter security."
2. **Implementation Challenges**: While the implementation of ZTA is considered effective, there are challenges in terms of training and adaptation for non-technical users, such as lecturers and students. Most of them are unfamiliar with the concept of Zero Trust and have difficulty understanding the stricter authentication procedures.

3. **Impact on Security**: The system manager states that ZTA has reduced the incidence of internal and external data leaks, but periodic evaluations are still required to improve the system.

Findings from the Licensed Employee Questionnaire

Findings from interviews reveal that ZTA implementation significantly enhanced access control and reduced unauthorized access. These results align with earlier findings by Bertino et al. (2020) and Chung et al. (2021), but this study adds evidence specific to academic environments. Participants reported initial resistance due to unfamiliarity with multi-factor authentication, underscoring the need for training (Al-Ahmad & Al-Fagih, 2021). User satisfaction data show that while security improved, usability declined slightly, echoing concerns by Kim & Solomon (2022) regarding the trade-off between security and user experience. These findings underscore the critical balance between cybersecurity advancement and user-centric system design in academic environments (Rani & Dey, 2023).

The results of a questionnaire filled out by licensed employees showed that 80% of respondents agreed that ZTA provides better control over academic data. However, 40% of respondents revealed that the repetitive identity verification process feels disruptive in daily activities. The questionnaire data illustrates that although ZTA improves the level of security, there are constraints in terms of user convenience.

Observation Results

Direct observation of ZTA implementation in three universities shows that:

- **Strict Access Control**: A security system based on ZTA verifies each user before accessing academic data, with the use of multi-factor authentication (MFA). This has been shown to reduce the risk of unauthorized access.
- **Data Surveillance**: There is stricter monitoring of user activity, which records every action taken on academic data. Users can only access information that is relevant to their role, and any conversations or data changes are well recorded.
- **Device Roles**: ZTA implements strict controls on the devices used to access the system. Users can only access the system through registered devices.

Visualization of Findings

Here are some graphs illustrating the findings in this study:

1. **User Satisfaction Graph with ZTA**
   This graph shows the level of user satisfaction with the ZTA implementation in terms of security and convenience. (Source: User Questionnaire Results)

2. **ZTA Implementation Evaluation Table**
The following table shows the IT team's evaluation of ZTA's effectiveness in reducing the risk of data leakage.

Aspects	Evaluation Score (1-5)
Data Leak Reduction	4.5
Effectiveness of Access Control	4.2
User Satisfaction	3.8
Implementation Difficulty Level	3.4

Discussion

Interview Data and Interpretation of Interview Results

Interviews with IT teams and system administrators revealed that Zero Trust Architecture was highly effective at improving access control and verifying user identities, which previously relied on a perimeter security model. These results support previous research by *Bertino et al. (2020)* which showed that ZTA is able to minimize potential threats from inside and outside the organization. However, the biggest challenge is the need to improve the understanding of non-technical users regarding the ZTA concept, which creates barriers in its implementation.

Discussion of Questionnaire Results

The results of the questionnaire showed that while users agreed that ZTA improved security, most felt that the repetitive authentication process interfered with their convenience. This is in line with the findings of *Chung et al. (2021),* who stated that although ZTA improves access control, the repetitive verification process can affect user convenience. Therefore, a more user-friendly approach is needed to increase user acceptance of this system.

Analysis of Observation Results

Observations show that ZTA-based systems provide stricter oversight of data access and devices used. This is in line with research by *Bertino et al. (2020)* which revealed that ZTA allows organizations to verify the identities of users and devices more rigorously. The use of multi-factor authentication and stricter surveillance has been shown to improve security levels, but requires adjustments for users who are used to simpler systems.

Comparison with Previous Research

This research is in line with research conducted by *Chung et al. (2021)* which also concluded that ZTA can improve the security of cloud-based systems. However, the main difference is that the focus of this study is on the education sector, which has particular challenges related to user

understanding and adaptation to new technologies. This research adds insight that the implementation of ZTA in the education sector needs to be supported by training and socialization to users.

Practical Implications

In practical terms, this study shows that while ZTA provides a better layer of security, it is important to provide training and support to users in order to adapt to more stringent authentication systems. In addition, system managers need to consider the user's convenience without compromising the level of security.

Research Limitations

This study has several limitations, such as the limited number of respondents limited to three universities, which may not fully represent all educational institutions in Indonesia. In addition, this study focuses more on ZTA implementation in general, and has not tested more specific solutions to address user convenience challenges in ZTA implementation

D. Conclusion

This study concludes that the integration of Zero Trust Architecture (ZTA) in the design of cloud-based academic information systems can significantly improve data security in educational institutions. The implementation of ZTA has succeeded in tightening access controls, verifying user identities, and ensuring that sensitive data can only be accessed by the authorities. Nonetheless, the main challenge faced is the adaptation of users, especially lecturers and students, to more stringent authentication procedures, which can reduce their convenience.

The results of the interviews and questionnaires showed that although respondents felt an increase in security, they also faced difficulties in understanding new procedures and more complicated verification processes. Therefore, intensive training and effective socialization strategies are needed to increase understanding and acceptance of ZTA. In addition, the study also shows that while ZTA provides better solutions for data security, successful implementation relies heavily on a balance between security and user convenience. ZTA makes a significant contribution to strengthening the security layer of cloud-based academic information systems, but to ensure its success, it is important to support it with a more inclusive and easy-to-understand approach for all parties involved.

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