Matrik: Jurnal Manajemen, Teknik Informatika, dan Rekayasa Komputer
Vol. 22, No. 2, Maret 2023, pp. 339∼352
ISSN: 2476-9843, accredited by Kemenristekdikti, Decree No: 200/M/KPT/2020
DOI: 10.30812/matrik.v22i2.2780

Blockchain-based Trust, Transparent, Traceable Modeling on Learning Recognition System *Kampus Merdeka*

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Article Info

Article history:

Received February 21, 2023
Revised March 04, 2023
Accepted March 20, 2023

Keywords:

Blockchain
Kampus Merdeka
Learning Recognition System
Model
Smart Contract

ABSTRACT

Kampus Merdeka is an evolution of education in Indonesia that accommodates various changes. The existence of a mechanism that includes various actors in it makes *Kampus Merdeka* have many new outcomes which must be recognized by all stakeholders who need it. Blockchain technology and smart contract offer the ability to build trust between all actors in the *Kampus Merdeka* activities with their transparent nature and reliable, immutable data storage capabilities. Every stage that occurs in it can be traced from upstream to downstream. This study aims to design an architectural model of a blockchain system for the learning recognition system *Kampus Merdeka*. It uses the analytical study to identify the possible problems and the stakeholders involved and design the model solution proposed. As a result, it proposed the type of blockchain and the most suitable architecture for use in the learning recognition system *Kampus Merdeka*. In this study, the blockchain model is proposed as a mechanism for identifying and recognizing learning outcomes in the *Kampus Merdeka* environment more securely, challenging to modify, and traceable by all parties to ensure the authenticity of the learning outcomes. Furthermore, it can be recognized by all parties in it.

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How to Cite:I. Afrianto, A. Heryandi, and S. Atin, "Blockchain-based Trust, Transparent, Traceable Modeling on Learning Recognition System Kampus Merdeka", *MATRIK : Jurnal Manajemen, Teknik Informatika dan Rekayasa Komputer*, vol. 22, no. 2, pp. 339-352, Mar. 2023.

1. INTRODUCTION

Kampus Merdeka is a breakthrough in the era of the industrial revolution 4.0 as a condition that students will face as a change for the better. The *Kampus Merdeka* concept is an effort to improve the higher education system that is ready to face the challenges of the times [1]. There are four central independent learning policies at the Merdeka Campus: the opening of new study programs, a higher education accreditation system, state universities with legal entities, and the right to study for three semesters outside the study program. The learning process in the Merdeka Campus includes activities inside and outside the study program, with eight learning activities that can be developed [2]. The policy must be followed by regulations so that technology can accommodate these activities adequately, safely, and reliably [3].

Blockchain is a ledger system (master ledger) with a record of every transaction that has ever existed in the form of a decentralized database network [4]. Blockchain technology can be applied in an environment with many services, such as an enterprise system [5]. Blockchain can function as a private or public blockchain [6]. In addition, blockchain technology can also receive data, validate, and provide trust and data for those who need it [7]. Blockchain is believed to have great potential to facilitate a business process when combined with innovative contract technology [8]. Smart contracts are computerized transaction protocols that execute contract clauses [9]. Although intelligent contracts were introduced in the nineties, blockchain was the first technology that could officially support their implementation [10]. In the literature, intelligent contracts and blockchain technology are inseparable terms forming second-generation blockchain technology [11]. One of the capabilities of blockchain is in the field of archives, where the main problem that can be solved with blockchain technology is the concept of trust required by archives so that archives are authentic. Archives need an instrument of trust so that their archive is reliable and can be trusted by more than one party [12]. In addition, in education, blockchain can be used as a facilitator to verify the authenticity of job training certificates [13] and online job and project transactions with a high level of trust and transparency [14].

The difference with previous blockchain research in the educational environment is that the model developed is a system for recognizing the results of learning by students involving the organizing universities and other external parties, whose role is to input and evaluate learning outcomes in the *Kampus Merdeka* national program. The purpose of this research is to learn how to record data during the learning process in the *Kampus Merdeka* program so that the data becomes data that is safe, difficult to fake, can be accessed, verified, and divided by all parties, and easy to trace so that the authentication becomes more secure with using blockchain technology.

2. RESEARCH METHOD

This section explains the literature review on blockchain technology, smart contracts, *Kampus Merdeka*, and the research flow to achieve objectives.

2.1. Blockchain Technology

Figure 1 illustrates a blockchain, an indelible data structure formed by a series of data blocks connected linearly in a time sequence [15]. Information is stored in each block and encrypted with asymmetric cryptographic algorithms to ensure the security of data access and transmission. The characteristics of blockchain technology that can be excelled are decentralization (decentralization): blockchain consists of peer-to-peer blocks, which can record and store all transactions [16], distributed trust (distrusting): because blockchain technology is implemented in a decentralized system, transfer data between nodes in the network does not require mutual trust among the participants [17], transparency (transparency): through the blockchain, all participants share records and requests for data in nodes in a decentralized structure [18], traceable and unforgeable: blockchain uses timestamps to identify and record each transaction, thereby increasing the time dimension of data [19], anonymity: blockchain encrypts data using asymmetric encryption techniques. This asymmetric encryption has two uses in blockchains: data encryption and digital signatures. Data encryption in the blockchain ensures transaction data security and reduces the risk of losing or falsifying transaction data [20]. Credibility: blockchain data exchange entirely depends on each node to form robust computations to defend against external attacks without human intervention [21].

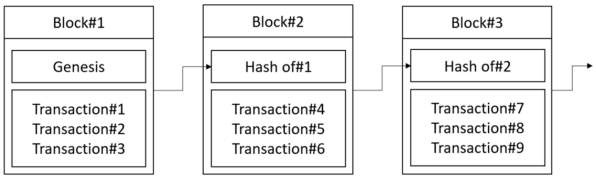

Figure 1. Blockchain illustration

2.2. Smart Contract

The subsequent development of blockchain is called Blockchain 2.0. The use of blockchain technology is wider by taking advantage of the revolution of a new mechanism called intelligent contracts (Figure 2). A smart contract is a contract built with the specific purpose of executing a complete set of instructions on the blockchain [22, 23]. Smart contracts are computer programs that contain contractual agreements between entities, which are generated by the user and extracted by the environment (blockchain). The purpose of smart contracts is for efficiency, security, and independence in the agreement, reducing contract implementation costs and increasing trust between entities [24]. The contract is a mechanism involving digital assets and two or more parties. Some or all parties enter assets, which are automatically redistributed among users according to a formula, on specific data unknown when the contract is initiated [25]. Based on the mechanism, intelligent contracts have five stages of development, namely: 1) negotiation; 2) development; 3) deployment; 4) maintenance; and 5) learning and self-destruction [26]. Smart contracts can reduce human intervention in business process flows in a system environment [27] and have automatic audit capabilities so that contacts and work that users should do can be completed more quickly and efficiently [28].

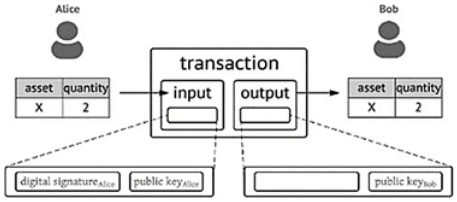

Figure 2. Smart contract concept

2.3. *Kampus Merdeka* Freedom of Learning

The *Kampus Merdeka* Program includes four central policies, namely: the ease of opening new study programs, changes to the higher education accreditation system, the ease of universities becoming legal entities, and the right to study for three semesters outside the study program. Students are given the freedom to take credits outside the study program. The intended three semesters can be taken for learning outside the study program in college and or learning outside the university (Figure 3).

Figure 3. Legal basis of *Kampus Merdeka*

Figure 4 shows the forms of learning activities that can be carried out within the Study Program and outside the Study Program, including student exchanges, internships/work practices, teaching assistant in the Education unit, research/research, humanitarian projects, entrepreneurial activities, independent studies/projects, village building/lectures thematic real work. Learning activities outside universities include internships/work practices, village projects, school teaching, student exchanges, research, entrepreneurial activities, independent studies/projects, and humanitarian projects that are as easy as activities that lecturers must guide.

Figure 4. Forms of Kampus Merdeka learning activities

Kampus Merdeka is expected to provide contextual field experiences that will improve student competencies and are ready to work. The learning process in the Merdeka Campus is one of the essential manifestations of student-centered learning. Learning in the Merdeka Campus provides challenges and opportunities for the development of creativity, capacity, personality, and student needs, as well as developing independence in seeking and finding knowledge through realities and field dynamics such as ability requirements, real problems, social interaction, collaboration, self-management, performance demands, targets, and achievements. Through Merdeka Learning Merdeka Campus is expected to be able to answer the challenges of higher education to produce graduates according to the development of science and technology and the demands of the business world and the industrial world [29]. The flow of the implementation of *Kampus Merdeka* activities can be seen in Figure 5.

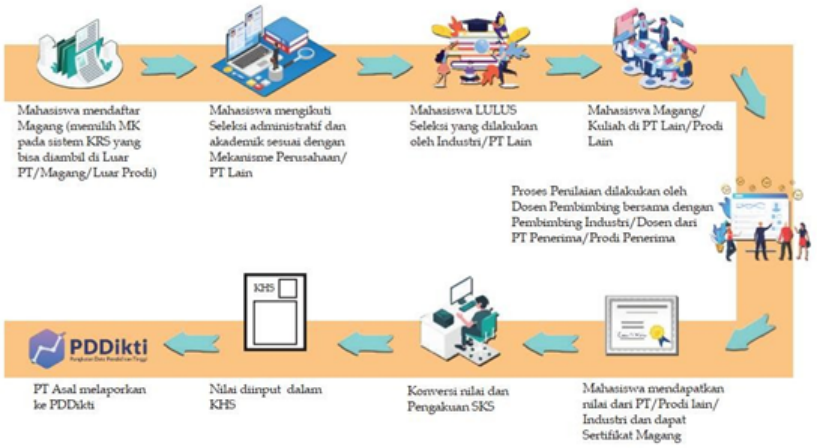

Figure 5. Mechanism of implementing *Kampus Merdeka* activities

2.4. Flow of Research

The approach used in this study is a quantitative approach using a descriptive method, namely conducting a comparative study to compare the phenomena found and make a classification based on a standard [30]. The research method carried out includes three stages of research activities (Figure 6) which include:

1. Problem identification is carried out at the beginning of the study by collecting literature that supports research and data from primary and secondary sources that are useful for supporting research. The achievement indicator at this stage is the acquisition of comprehensive and sufficient research data as research data to be used in the development of the proposed model.
2. Development of a blockchain-based *Kampus Merdeka* learning recognition model, the research phase in this section begins with the requirements engineering analysis stage of the Blockchain-based *Kampus Merdeka* learning outcomes recognition system, which includes functional requirements analysis activities, non-functional requirements analysis, domain requirements analysis, user requirements analysis and analysis of system requirements. The next stage is to design a blockchain-based learning recognition system model for *Kampus Merdeka*, which includes activities to develop a conceptual model, transparency model, trust model, traceability model, and data model for the *Kampus Merdeka* learning recognition system. The indicator of achievement at this stage of this research is the analysis and design of software that can be a model for the recognition system for learning outcomes of the *Kampus Merdeka* based on blockchain.
3. Research results in the final stage of this research are to produce a conclusion from the research conducted in the form of the results that have been achieved and future work for this research.

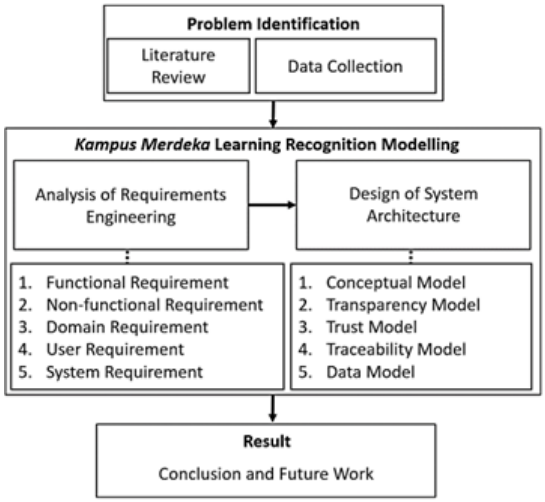

Figure 6. Research flow

3. RESULT AND ANALYSIS

3.1. System modeling

The blockchain-based *Kampus Merdeka* learning recognition system model was developed to facilitate *Kampus Merdeka* program management activities that are carried out transparently, safely, and reliably. A blockchain-based system is proposed because the parties involved in *Kampus Merdeka* activities do not only come from universities but from other parties who need guarantees of openness and transparency of *Kampus Merdeka* program data. The model is designed based on an online web so that it can be accessed by various parties (users) whenever and wherever they are. Users of the system model are entities in the Unikom academic environment according to their functions and roles and external users in the *Kampus Merdeka* activity environment. The recognition system model is designed to retrieve data from systems that Unikom, such as guardianship, achievement, and academic applications, have previously developed. The mechanism for retrieving data from the Unikom system is carried out so that there is no duplication and redundancy of academic data. The basic functionalities in this recognition system model include functional data input, data validation, and validation of *Kampus Merdeka* program results. The system developed requires users such as students to complete their student profiles regarding their achievements, workshops, training, and certifications.

Meanwhile, the Study Program and Academic Section enter guardianship data and other supporting academic data. The Vice

Rector, the relevant Directorate, the PIC, and the Head of the Study Program must verify the data entered into the system by providing the necessary recommendations. Meanwhile, partners can use the system to enter data on the value of the *Kampus Merdeka* process, which will later be processed by the PIC and Study Program, to balance the credits and *Kampus Merdeka* courses. The intelligent contract stores all transaction data in the *Kampus Merdeka* activity in the blockchain system. The recognition result documents can be accessed by users such as DIKTI, Deans, and other parties who need information related to the results/implementation of the *Kampus Merdeka* program by accessing the existing system. The recognition system architecture model can be seen in Figure 7.

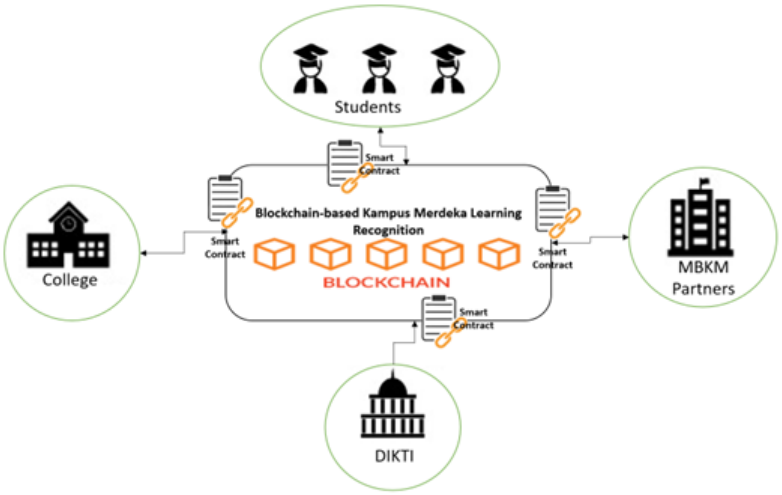

Figure 7. Blockchain-based *Kampus Merdeka* learning recognition model system

The system developed is a web-based system that users can access online. Each user is given different access rights according to their function and role in the system. The system was developed using a blockchain platform so that the transactions that occur in *Kampus Merdeka* activities can be more transparent, safer, and resistant to manipulation. Blockchain technology can distribute data to all users in the system so that all users have the same data in their activities. The distributed data system is important to maintain the integrity of transaction data that occurs in *Kampus Merdeka* activities to increase trust in data among *Kampus Merdeka* actors. The conceptual model of the system built can be seen in Figure 8.

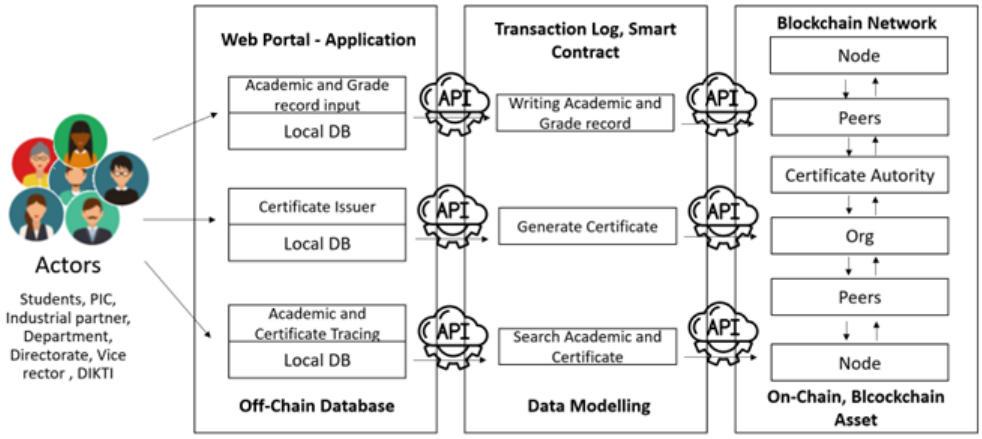

Figure 8. Conceptual model of blockchain-based *Kampus Merdeka* learning recognition

This blockchain transparency model on the *Kampus Merdeka* learning recognition system can be seen in Figure 9. For every *Kampus Merdeka* data transaction shared with all users, all users in the group will get a copy of the transaction. The copy is stored in a database connected with an application programming interface (API) [31]. Each node will communicate with the other with the help of the API. With this mechanism, data transparency in the *Kampus Merdeka* environment can be further improved.

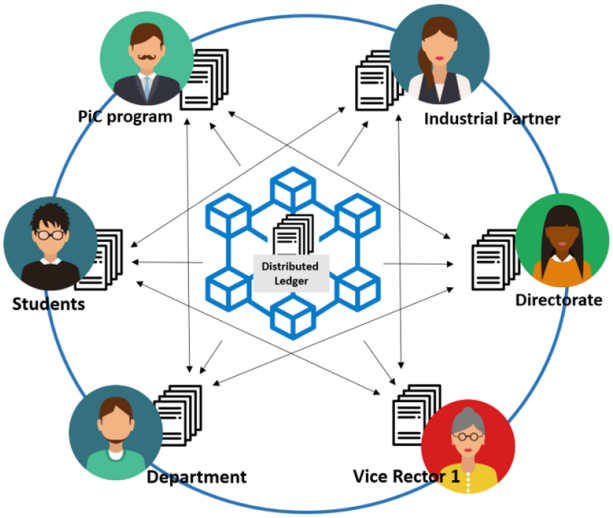

Figure 9. Blockchain-based *Kampus Merdeka* learning recognition transparency model

Meanwhile, figure 10 explains how blockchain can be used in the *Kampus Merdeka* environment to validate student *Kampus Merdeka* results. Blockchain technology uses cryptographic mechanisms and access control based on Certificate Authorization (CA) as its security [32]. The advantages and benefits of blockchain technology applied in the *Kampus Merdeka* environment are the reduced rates of fraud in counterfeiting a value due to transparency in the blockchain where every user connected in a network has the same record, and the record will be updated if all users are connected in the network agrees to the record. Thus, the stored records will be more accurate and consistent when compared to those without blockchain technology, increasing users trust in the *Kampus Merdeka* environment.

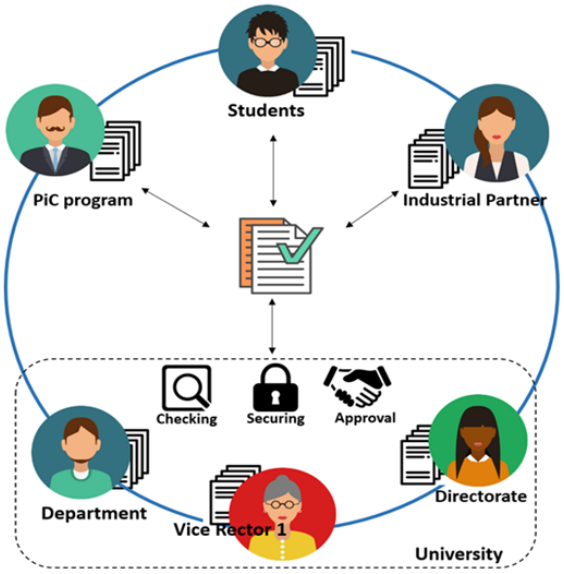

Figure 10. Blockchain-based *Kampus Merdeka* learning recognition trust model

Figure 11 describes the traceability mechanism in the *Kampus Merdeka* learning recognition model. Traceability is the ability of a system to recognize and trace data at every stage, from upstream to downstream [33]. For the *Kampus Merdeka* learning recognition system model, the primary purpose of the traceability system is to record/document data on learning programs within the *Kampus Merdeka*, from participant registration to verification of learning outcomes.

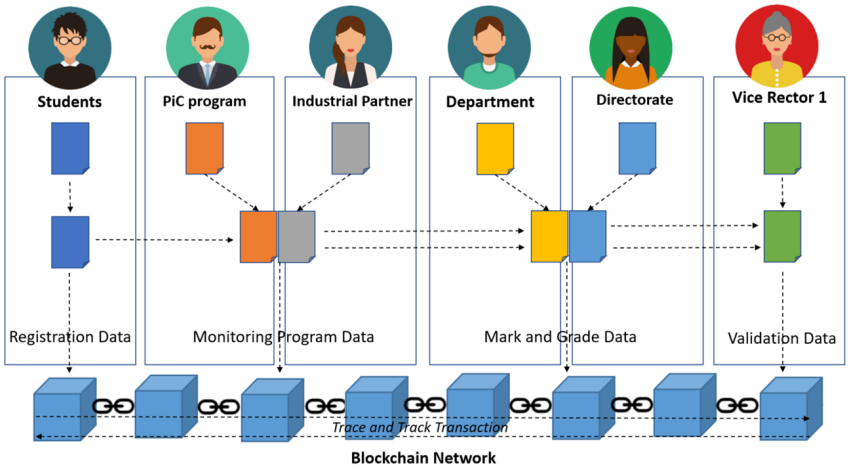

Figure 11. Blockchain-based *Kampus Merdeka* learning recognition traceability model

3.2. System functional model

Figure 12 shows the system requirements analysis model when it is implemented. This requirements analysis determines the inputs needed by the system, the processes used to process inputs into outputs, and the outputs to be generated by the system.

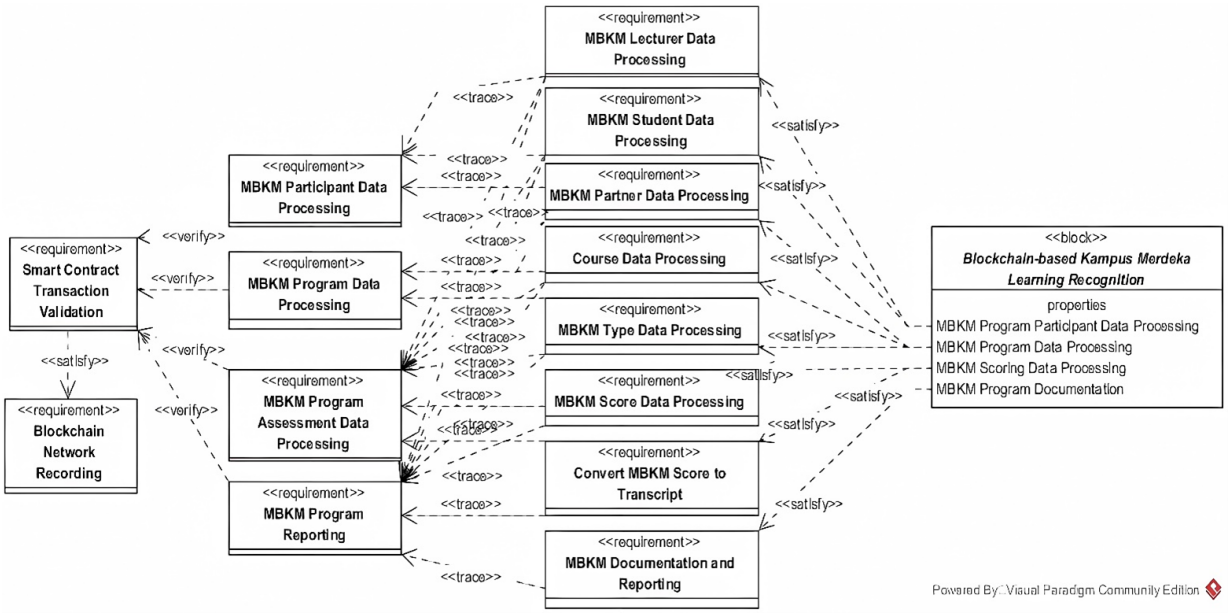

Figure 12. Requirements engineering analysis blockchain-based *Kampus Merdeka* learning recognition model

Functional modeling is done using use-case diagrams, use case scenarios. Use-case diagrams are constructions used to describe the relationships between actors and activities in the system. The target of use case modeling is to define the functional and operational requirements of the system by defining the scenario of using the system to be built. The use case diagram includes the actors involved in the system, as well as the functionalities that the actors can perform. The use case diagram for the *Kampus Merdeka* learning recognition model based on the blockchain can be seen in Figure 13.

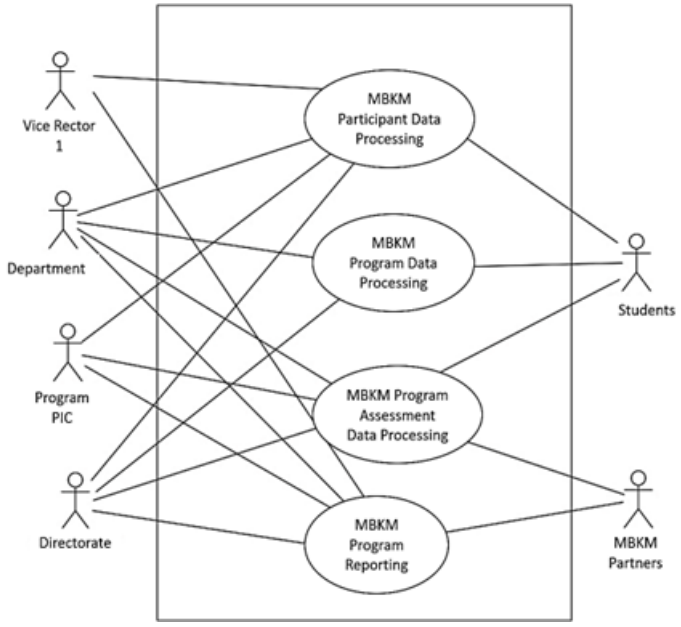

Figure 13. Use case diagram of a blockchain-based *Kampus Merdeka* learning recognition model

Diagram The use case diagram is assisted by the definition of each use case for ease of available translation of the use case, which can be seen in Table 1.

Table 1. Use Case Definition of Blockchain-Based *Kampus Merdeka* Learning Recognition Model

No	Use Case	Description
1	Kampus Merdeka Participant Data Processing	The process used to record *Kampus Merdeka*, program participants
2	Kampus Merdeka Activity Data Processing	The process used to record activities carried out by the *Kampus Merdeka* program.
3	Kampus Merdeka Assessment Data Processing	The process used for recording the assessment results and certificates obtained by Merdeka Campus program participants.
4	Kampus Merdeka Reporting Data Processing	The process used to generate reports on the Kampus Merdeka program

3.3. Data Modelling

The data transaction model used in developing a blockchain-based *Kampus Merdeka* learning recognition system model uses an existing database in the academic system, plus several new tables to generate *Kampus Merdeka* data. The proposed database changes in this model can be seen in Figure 14. The proposed model for developing data management in the *Kampus Merdeka* learning recognition system combines on-chain and off-chain transactions. On-chain transactions are types of transactions that are recorded directly on the blockchain network. On-chain transactions require validation from the validator node. This type of transaction is considered valid with the blockchain records being updated so that they can represent transactions in the public ledger. Meanwhile, off-chain transactions are a mechanism for transactions carried out outside the blockchain network, which has the advantage of speed because it does not require node validation in the blockchain environment [34].

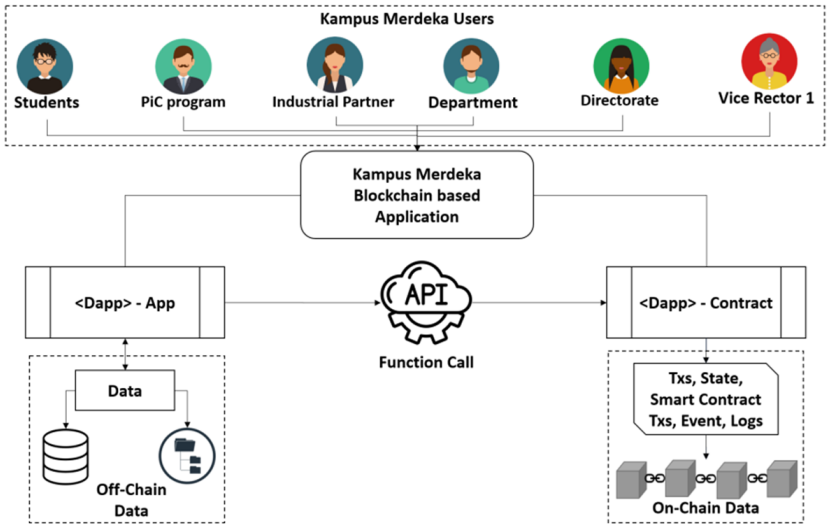

Figure 14. Proposed data modeling in blockchain-based *Kampus Merdeka* learning recognition system

This research has produced a blockchain technology architectural model for the learning recognition system at *Kampus Merdeka*. This research is in line with research [35, 36], where the development of the model starts from re-engineering existing business processes and designing user requirements. Meanwhile, according to research, distributed and decentralized functions were applied to guard the integrity and transparency of data [37]. The ability to validate research is carried out to maintain the authenticity of the data, which has implications for increasing trust between users in the system. The utilization of smart contracts in the proposed system is used to guarantee the authenticity and ease of tracking data as in research [38]. Meanwhile, the traceability model is intended to make it easier for users to browse the data stored in the system and to see its authenticity and origin [39]. However, this research has only been completed at the model development stage, so it needs to be continued in prototype development [40] and system testing [41], where data, transactions, security, and APIs are used, and the blockchain platform has been tested.

4. CONCLUSION

This research has produced a blockchain technology architectural model for the learning recognition system at *Kampus Merdeka*. The resulting model is a transaction transparency model in the *Kampus Merdeka* environment, a trust recognition model for activities at *Kampus Merdeka*, and a data traceability model for activities within *Kampus Merdeka*. The trust model in the *Kampus Merdeka* recognition system is obtained by applying the identity of users who can access the system, every user connected to a network has the same record, and the record will be updated if all users connected to the network agree on the record. Meanwhile, the transparency model in the *Kampus Merdeka* is facilitated by a decentralized blockchain environment, where transaction data is distributed and stored across all users. The decentralized blockchain environment allows all users to know and get the same data to maintain data transparency within the Merdeka Campus environment. The data traceability model in the *Kampus Merdeka* recognition system is obtained by connecting the data inputted by each user into a single blockchain. Stakeholders from downstream to upstream will easily trace the data to maintain the authentication and origin of the data. The contribution produced by this research is a model for recognizing *Kampus Merdeka* learning outcomes that is more transparent, trusted, and traceable with safer data on the blockchain. This research is still an architectural and conceptual model that can be developed towards a more technical prototype and implementation in the future. Meanwhile, the challenge of developing blockchain technology in the education environment in Indonesia is that because this technology is still relatively new, several issues need to be considered when adopting blockchain technology in education in Indonesia, such as the absence of laws governing blockchain technology in education, the problem of adoption costs, the risk of blockchain technology failure, the readiness of blockchain resources, and the shortcomings of blockchain technology itself.

5. ACKNOWLEDGEMENTS

The researchers would like to thank the Universitas Komputer Indonesia, Directorate of Research, Service, and Community Empowerment (DP3M) UNIKOM for the assistance of the Internal Fundamental Research Grant in 2021. We also thank the management of the *Kampus Merdeka* of the Universitas Komputer Indonesia for their cooperation and assistance in support of this research.

6. DECLARATIONS

AUTHOR CONTIBUTION

The first author contributed to developing the research idea, writing the content and conclusion of this research. Meanwhile, the second and third authors contributed to developing the proposed system model. The discussion, the writing of the research article, and the agreement of the contents of this research article have been approved by all authors.

FUNDING STATEMENT

This research was funded by an internal grant from Universitas Komputer Indonesia in 2022 and is one of the outcomes of the grant activities.

COMPETING INTEREST

The authors declare that they have no competing financial/non-financial, professional, or personal interests that could influence the research reported in this article.

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