Benefits Provided by Blockchain Technology in the Field of Education

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Abstract

The revolution in a technology certainly provides new innovations that are more creative and effective than previous technologies where the technology is called a ledger (blockchain technology). Blockchain technology is known as bitcoin or digital currency that can be used anywhere without a third party when making a transaction. The development of blockchain technology used in crypto has been applied in the field of education. The system contained in blockchain technology has a data center with distribution that will be distributed in each computer network to serve as a data base or data center that contains information in digital form. However, the popularity of blockchain technology is still many who do not know what blockchain technology can provide for education in today's digital age, for this reason this research paper aims to inform that there are several benefits that will be received in the field of education from the application of blockchain technology. The use of blockchain technology has become global so that more information is needed in providing concrete examples that have obtained the results of implementing blockchain technology so that Indonesian education can compete in the world because it does not lag behind the use of technology in education as a place for data storage and security. Literature review is the method of this research by looking for previous research that has been published with the same theme. And this research uses the slovin method, which is a calculation method. This research paper encourages further researchers to be able to provide education about blockchain technology in national and international forums...

Keywords: *Blockchain technology, education, benefits*

1. Introduction

The popularity of technology every year is definitely one of human efforts in providing new innovations in the field of technology that can adapt human life in daily activities, both for the lower and upper classes of society[1]. The growth of Indonesia's population certainly encourages people to be able to think more creatively in creating things like technology because human life already depends on the name of technology where and at any time without knowing the time and circumstances of course[2]. Blockchain technology is a new technology that is very popular in the world and in Indonesia. Even the application of blockchain technology has resulted in significant collaboration in all fields without exception[3]. The ledger or blockchain technology itself has components that can be seen in the image below:

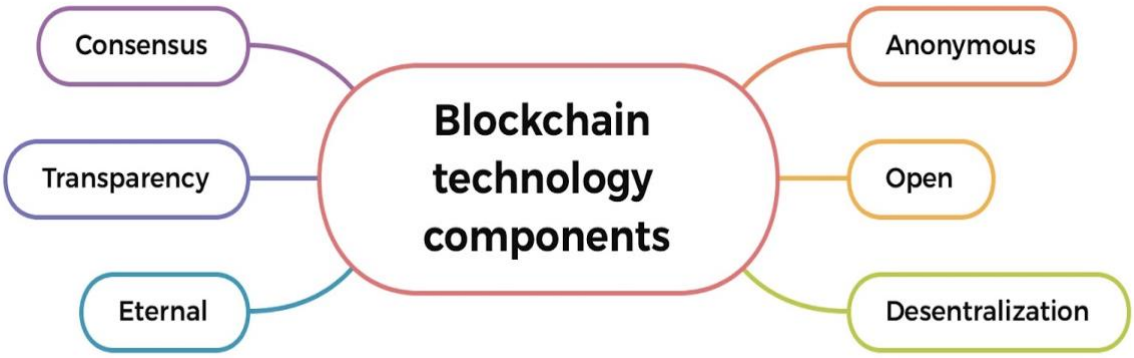

Figure 1. Blockchain technology components

The description of these components has the following meaning:

1. Anonymous means that the data is spread across blockchain technology and is anonymous because the incoming data will be processed using hashing, a technique that hides information about the data[4].
2. Open means that most blockchain technology systems are made in order to be able to change a desired program and as needed by using the system code because it is to facilitate work with the parties concerned[5].
3. Decentralization means that computer systems connected to blockchain technology do not depend on networks (nodes), because all connected networks (nodes) can record, store and update data[6].
4. Eternal means that data that has been stored in blockchain technology cannot be changed unless someone knows 51% of the node and it will be stored forever[7]
5. Transparency means that the data contained in the block in blockchain technology has been recorded and will be scattered across each network or node[8].
6. Basic consensus means that if there is a change contained in blockchain technology, it can change if there is an agreement between the two parties (consensus) of the magnitude or majority related to the blockchain[9].

The ledger in question is another name for blockchain technology that has data processing but does not have a form (one entity) on a computer or the database (record) on blockchain technology turns out to be developing[10], the connected blocks are of course stored neatly and secured using techniques. The network owned by blockchain technology does not have centralized authority (democratization). Each block of data has a cryptographic hash which is bound in principle through the first block to the timestamp and transaction processing. The performance of the blockchain itself is always connected to the network (nodes) that are tied to each other[11]. Peer-to-peer is the main blockchain network by containing the function (torrent) or peer-to-peer network in carrying out the sharing process[12]. Each computer that is connected to the network (node) will be verified on the blockchain technology on the chain and generate a unique code as a characteristic of the blockchain. The technology has a combination of techniques such as mathematics[13], algorithms, distributed consensus algorithms and cryptography known as blockchain or ledgers[14].

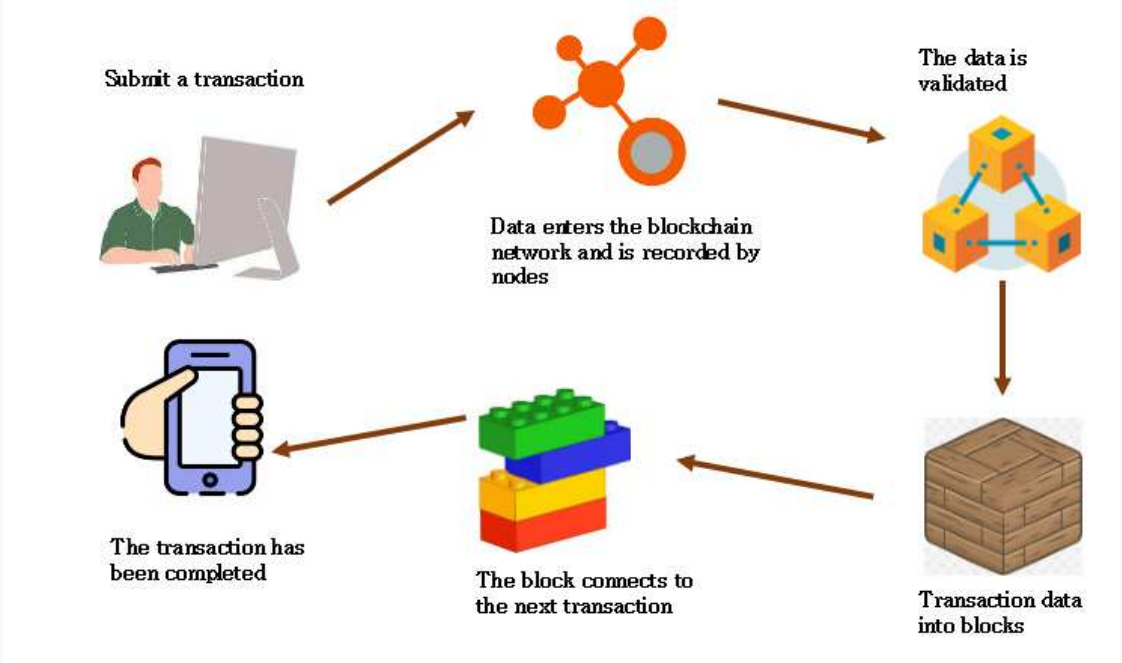

Figure 2. How blockchain technology works

It can be seen from Figure 2 above that the system that is carried out when carrying out the work process on blockchain technology can be explained as follows[15]:

a. There is a submission from a party who wants to make a transaction on a computer or system that is already available with[16].
b. Transactions made will go to a network or node on blockchain technology and go through a validation process for the data[17].
c. After validation is carried out by an algorithm on the blockchain network, of course it contains transaction recording and storage activities in the box.
d. New data that has been validated at the time of making a transaction must be a data block that will be connected to other data blocks[13].
e. Blocks that are already connected to other blocks on the blockchain technology network will not be able to be changed by other parties because there is a unique parameter (encryption hash code) that is permanently connected in its path[18].
f. This stage is the completion of the initial transaction because it has been validated and the data transaction has a valid final result with a code that can be checked for authenticity[19].

The explanation above shows that blockchain technology is a technology with a security system that is neatly stored and has a large storage area, so it can be used in the education sector in terms of protecting important data in the form of certificates, diplomas and can also be used in the learning process[20].

2. Research Method

This study uses a literature review method by looking for previous and published research with the same theme in previous studies, not only that this research uses the slovin method[21], which is a method by performing a calculation. Where the period of time required is seven days starting from January 15 to January 21, 2022. The existence of blockchain

technology is a step in implementing new innovations as implementation in the field of education because it can help improve the quality of the education sector in terms of quality technology.

2.1 Literature Review

To strengthen this research, there are five research papers with themes that have been and have been published, of course, which include[19]:

1. Blockchain technology has been widely used in universities as an epidemic in data storage[22] and a place to conduct data transactions by having a trusted system[23].
2. Blockchain technology has been used as a security system in digital certificates, so that certificates can be checked for authenticity[24] from the code that has been listed so that a company can see if the certificate given is genuine or fake[25].
3. Blockchain technology is a medium that can reduce costs when carrying out a transaction because it is not needed by a third party, because both parties already have trust so that transactions[26] can be done anytime and anywhere (time efficiency)[27].
4. Blockchain technology has a security system using a peer-to-peer network (node) that is connected[28] to the network and connected to computers[29].
5. Blockchain technology itself can perform a validation on data that is carried out during transactions and verified with an encryption hash code on a network on blockchain technology[30].

2.2 Slovin Method

The research paper with the title of the benefits provided by blockchain technology in the field of education[31], will involve 30 data through a sampling technique, namely its distribution through social media questionnaires in the form of whatsapp[32], instagram and facebook[33]. The calculation method using slovin has provisions for the data to use 30 people with a margin of error with a determination of 1% or 0.01. The data is filled in by several students from universities[34].

$$\mathrm{n} = \frac{N}{(1 + N.e^2)}$$

$$\mathrm{n} = \frac{30}{(1 + 30\ x\ 0{,}05^2)}$$

$$\mathrm{n} = \frac{30}{(1 + 30\ x\ 0{,}0025)}$$

$$\mathrm{n} = \frac{30}{(1 + 0{,}075)}$$

$$\mathrm{n} = \frac{30}{(1{,}075)}$$

$$\mathrm{n} = \mathbf{27.906} \text{ round to } \mathbf{28}$$

The results of these calculations there are 30 people as a benchmark sample that is used as a minimum data of 30 people as research respondents in the benefits of technology in the field of education which will be applied as a data storage system and data transaction[35].

3. Findings

3.1 A Brief History of Blockchain Technology

When you read the name Satoshi Nakamoto in previous articles and research papers, you

must have come across as a figure in the discovery of blockchain technology in 2008, where blockchain technology has developed three times[36], as follows[12]: [a] The first batch of blockchain is known as the emergence of bitcoin (money). digital) and is used on cryptocurrencies using cryptographic techniques to have a function as application security when making transactions[37]. [b] Blockchain with the second batch is implemented for finance in the form of services using smart contracts[38]. The platform used on the blockchain uses the ethereum network[39]. and [c] Blockchain with the third batch of implementation or implementation of blockchain technology is more flexible because it has been applied to applications such as the financial industry and industry in general (education, government, health, and others)[40].

3.2 Blockchain Technology Structure

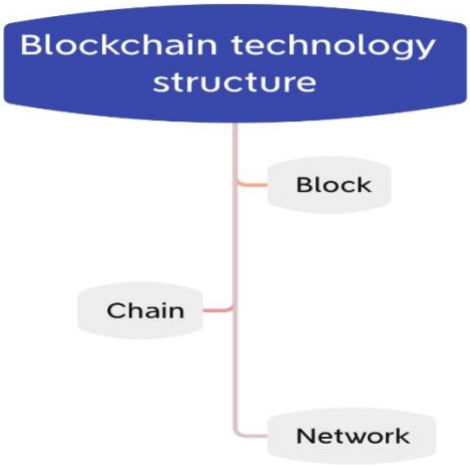

Figure 3. Blockchain Technology Structure

a) Block, is a representation of a list of valid transactions stored in blockchain technology, a block that has a cryptographic hash and contains the identity of each connected block[41]. There are components on the network in blockchain technology (block size, block header, number of records and list of transactions)[42]

b) The chain has a role in connecting each block on blockchain technology in the form of a hash. It turns out that hash as the creator of the algorithm has mathematically mapped data with various sizes in 32 bit characters. The algorithm used by the blockchain, namely SHA-256, can change the size to 256 bits on the data hash character[43].

c) The network on the blockchain is a representation of many nodes on a computer that are connected to each other in running a network algorithm (nodes). The peer-to-peer network that uses blockchain technology is found in all fund nodes communicating to get messages or send messages[44].

3.3 The Benefits of Blockchain Technology in Several Fields of Finance, Health, Law and Education.

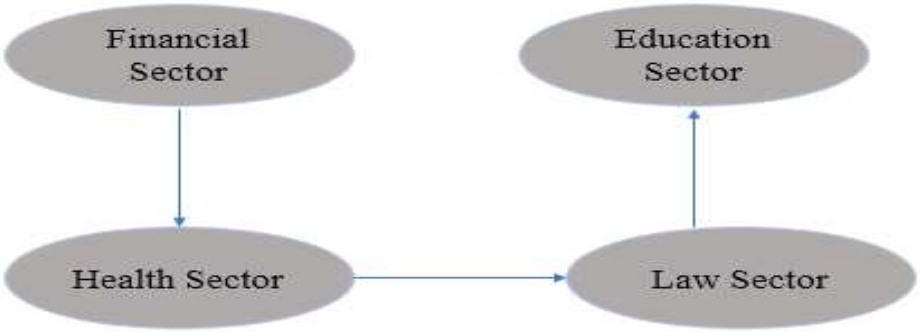

Figure 4. Finance, Health, Law and Education.

1. **In the financial sector**, when conducting a digital currency transaction (cryptocurrency) it takes a platform that can be connected to the internet network and when making transactions more secure[45].
2. **The health sector** provides the benefits of implementing blockchain technology, namely the safe storage of health data history that can be viewed and accessed digitally in medical records[46], there is no need for paper with data storage in stacks in cupboards and inefficient search times in time and effort[47].
3. **The legal field**[48], such as the storage of evidence during the judicial process can be stored safely because it cannot be changed so that data falsification does not occur because the application of blockchain and the storage of important files is more authentic, can be stored a lot and is easy to find and access anywhere[49].
4. **In the field of education**, blockchain technology is famous at this time in the field of education not to be outdone in applying[50] this technology because of the many benefits that can be provided in the field of education as follows:
   a. **The lecturer certification program**, it is known that lecturers need a certification that is useful as a form of appreciation for lecturers because they have become experts[16] in the profession who are empowered to require a technology that can overcome the problem of certificate counterfeiting, where blockchain technology is a solution to this problem because it contains technology with database that is well distributed and uses digital sha so that the integrity of the certificate is maintained through a digital format[51].
   b. **Certificate security at universities** where blockchain technology is used as a security system using encryption codes to avoid crimes such as doubling certificates and changing data on certificates so that these crimes often do not happen again[52].
   c. **The learning method using gamification** is a learning method with new innovations that can improve understanding when carrying out the teaching and learning process carried[53] out by students and lecturers so that students do not feel bored when learning because the method provided is in accordance with the times using the e-learning system[54].
   d. **Schedule LTAI** (Lightning Talk Alphabet Incubator) is an activity that is often carried out to be able to share knowledge about new things that have been obtained through a youtube channel called Magics Channel - Universitas Raharja. For that we need a programming language that can set the schedule on the google calendar using a script program language using blockchain technology,

namely encryption code, so that the schedule that has been made is safe[55].

e. **Quality improvement** in higher education is because the university dares to innovate in implementing new technology (blockchain), thereby encouraging the creativity of the lecturers to do new things so that resources such as students on campus are not left behind and confused about blockchain technology that can be used as a security system. and more efficient data storage, so that the university forms human resources that are rich with capabilities and ready to face technological changes that are increasingly developing day by day.

4. Conclusion

The application of blockchain technology has been widely applied in the fields of finance, health, law and education. The benefits obtained in the field of education such as certification programs for lecturers, certificate security, more enjoyable learning methods, making schedules or schedules and increasing quality at universities, because the development of blockchain technology can be well received by universities so that they can be managed and used properly in order to compete with other universities. Blockchain technology is a technology that is increasingly famous and has the uniqueness of the technology such as the presence of an encryption code using peer-to-peer nodes and connected to each other and validated, therefore parties who have no interest cannot change the data and delete it. the data because it is stored securely.

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References

[1] U. Rahardja, N. Lutfiani, A. D. Lestari, and E. B. P. Manurung, "Inovasi Perguruan Tinggi Raharja Dalam Era Disruptif Menggunakan Metodologi iLearning," *J. Ilm. Teknol. Inf. Asia*, vol. 13, no. 1, pp. 23–34, 2019.

[2] A. Asgaonkar and B. Krishnamachari, "Solving the buyer and seller's dilemma: A dual-deposit escrow smart contract for provably cheat-proof delivery and payment for a digital good without a trusted mediator," in *2019 IEEE International Conference on Blockchain and Cryptocurrency (ICBC)*, 2019, pp. 262–267.

[3] A. Dolgui, D. Ivanov, S. Potryasaev, B. Sokolov, M. Ivanova, and F. Werner, "Blockchain-oriented dynamic modelling of smart contract design and execution in the supply chain," *Int. J. Prod. Res.*, vol. 58, no. 7, pp. 2184–2199, 2020.

[4] S. Sayeed, H. Marco-Gisbert, and T. Caira, "Smart contract: Attacks and protections," *IEEE Access*, vol. 8, pp. 24416–24427, 2020.

[5] N. He, L. Wu, H. Wang, Y. Guo, and X. Jiang, "Characterizing code clones in the ethereum smart contract ecosystem," in *International Conference on Financial Cryptography and Data Security*, 2020, pp. 654–675.

[6] R. M. Parizi and A. Dehghantanha, "Smart contract programming languages on blockchains: An empirical evaluation of usability and security," in *International Conference on Blockchain*, 2018, pp. 75–91.

[7] Y. Zhuang, Z. Liu, P. Qian, Q. Liu, X. Wang, and Q. He, "Smart Contract Vulnerability Detection using Graph Neural Network.," in *IJCAI*, 2020, pp. 3283–3290.

[8] P. McCorry, S. F. Shahandashti, and F. Hao, "A smart contract for boardroom voting with maximum voter privacy," in *International Conference on Financial Cryptography and Data Security*, 2017, pp. 357–375.

[9] A. Khatoon, "A blockchain-based smart contract system for healthcare management," *Electronics*, vol. 9, no. 1, p. 94, 2020.

[10] V. No and E. Februari, "PENGARUH TEKNOLOGI BLOCKCHAIN TERHADAP TINGKAT KEASLIAN IJAZAH," *PENGARUH Teknol. BLOCKCHAIN TERHADAP TINGKAT KEASLIAN IJAZAH*, vol. 4, no. 2, 2020.

[11] D. Solihin, "The Influence Of Brand Image And Atmosphere Store On Purchase Decision For Samsung Brand Smartphone With Buying Intervention As Intervening Variables (Study on Samsung Experience Store Karawaci Customers)," *Int. J. Soc. Sci. Bus.*, vol. 5, no. 2, 2021.
[12] U. Rahardja, Q. Aini, M. Yusup, and A. Edliyanti, "Penerapan Teknologi Blockchain Sebagai Media Pengamanan Proses Transaksi E-Commerce," *CESS (Journal Comput. Eng. Syst. Sci.*, vol. 5, no. 1, p. 28, 2020, doi: 10.24114/cess.v5i1.14893.
[13] A. Pambudi, R. Widayanti, and P. Edastama, "Trust and Acceptance of E-Banking Technology Effect of Mediation on Customer Relationship Management Performance," *ADI J. Recent Innov.*, vol. 3, no. 1, pp. 87–96, 2021.
[14] S. Sutandi, "Pengaruh Big Data Dan Teknologi Blockchain Terhadap Model Bisnis Sektor Logistik Dengan Pendekatan Business Model Canvas," *J. Logistik Indones.*, vol. 2, no. 1, pp. 9–20, 2018, doi: 10.31334/jli.v2i1.214.
[15] E. Guustaaf, U. Rahardja, Q. Aini, N. A. Santoso, and N. P. L. Santoso, "Desain Kerangka Blockchain terhadap pendidikan: A Survey," *CESS (Journal Comput. Eng. Syst. Sci.*, vol. 6, no. 2, p. 236, 2021, doi: 10.24114/cess.v6i2.25099.
[16] E. Guustaaf, U. Rahardja, Q. Aini, and H. W. Maharani, "Blockchain-based Education Project," vol. 5, no. 1, 2021.
[17] U. Rahardja, M. D. Ngadi, R. Budiarto, Q. Aini, M. Hardini, and F. P. Oganda, "Education Exchange Storage Protocol: Transformation into Decentralized Learning Platform," in *Frontiers in Education*, p. 477.
[18] U. Rahardja, T. Hariguna, and Q. Aini, "Understanding the Impact of Determinants in Game Learning Acceptance: An Empirical Study.," *Int. J. Educ. Pract.*, vol. 7, no. 3, pp. 136–145, 2019.
[19] A. Yuliani, H. Nugroho, and S. Amelia, "Pendampingan Ibu Dalam Stimulasi Perkembangan Motorik Untuk Mengoptimalkan Tumbuh Kembang Balita di Kabupaten Pemalang," *ADI Pengabdi. Kpd. Masy.*, vol. 2, no. 1, pp. 57–61, 2021.
[20] P. Cuesta-Valiño, P. Gutiérrez-Rodríguez, and E. Núnez-Barriopedro, "The role of consumer happiness in brand loyalty: a model of the satisfaction and brand image in fashion," *Corp. Gov. Int. J. Bus. Soc.*, 2021.
[21] G. P. Widodo and M. Syukri, "Elements of Commerce Shows Enterprise Development Innovation Efficient Auditing and the Way of the Future," *ADI J. Recent Innov.*, vol. 3, no. 1, pp. 97–104, 2021.
[22] Q. Aini, A. Alwiyah, and D. M. Putri, "Effectiveness of Installment Payment Management Using Recurring Scheduling to Cashier Performance," *Aptisi Trans. Manag.*, vol. 3, no. 1, pp. 13–21, 2019.
[23] S. Wang, Y. Yuan, X. Wang, J. Li, R. Qin, and F.-Y. Wang, "An overview of smart contract: architecture, applications, and future trends," in *2018 IEEE Intelligent Vehicles Symposium (IV)*, 2018, pp. 108–113.
[24] A. G. Prawiyogi, Q. Aini, N. P. L. Santoso, N. Lutfiani, and H. L. J. Juniar, "Blockchain Education Concept 4.0: Student-Centered iLearning Blockchain Framework," *JTP-Jurnal Teknol. Pendidik.*, vol. 23, no. 2, pp. 129–145, 2021.
[25] A. Hahn, R. Singh, C.-C. Liu, and S. Chen, "Smart contract-based campus demonstration of decentralized transactive energy auctions," in *2017 IEEE Power & energy society innovative smart grid technologies conference (ISGT)*, 2017, pp. 1–5.
[26] P. A. M. Ruijten, "The similarity-attraction paradigm in persuasive technology: Effects of system and user personality on evaluations and persuasiveness of an interactive system," *Behav. Inf. Technol.*, vol. 40, no. 8, pp. 734–746, 2021.
[27] A. M. Younus and V. Raju, "Resilient Features of Organizational Culture in Implementation of Smart Contract Technology Blockchain In Iraqi Gas and Oil Companies," *Int. J. Qual. Res.*, vol. 15, no. 2, p. 435, 2021.
[28] J. V Petrocelli, "Bullshitting and persuasion: The persuasiveness of a disregard for the truth," *Br. J. Soc. Psychol.*, 2021.
[29] D. Perez and B. Livshits, "Smart contract vulnerabilities: Does anyone care?," *arXiv Prepr. arXiv1902.06710*, pp. 1–15, 2019.
[30] B. K. Mohanta, S. S. Panda, and D. Jena, "An overview of smart contract and use cases in blockchain technology," in *2018 9th International Conference on Computing, Communication and Networking Technologies (ICCCNT)*, 2018, pp. 1–4.
[31] D. Macrinici, C. Cartofeanu, and S. Gao, "Smart contract applications within blockchain

technology: A systematic mapping study," *Telemat. Informatics*, vol. 35, no. 8, pp. 2337–2354, 2018.

[32] Y. Huang, Y. Bian, R. Li, J. L. Zhao, and P. Shi, "Smart contract security: A software lifecycle perspective," *IEEE Access*, vol. 7, pp. 150184–150202, 2019.

[33] C. L. Kusnadi, N. Lutfiani, H. L. Juniar, and U. Rahardja, "Miu ai: Application based on the e-commerce prototype for japanese otaku in indonesia," *J. Adv. Res. Dyn. Control Syst.*, vol. 12, no. 6, pp. 618–623, 2020.

[34] M. Kim, B. Hilton, Z. Burks, and J. Reyes, "Integrating blockchain, smart contract-tokens, and IoT to design a food traceability solution," in *2018 IEEE 9th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON)*, 2018, pp. 335–340.

[35] I. Karamitsos, M. Papadaki, and N. B. Al Barghuthi, "Design of the blockchain smart contract: A use case for real estate," *J. Inf. Secur.*, vol. 9, no. 03, p. 177, 2018.

[36] I. K. Gunawan, N. Lutfiani, Q. Aini, F. M. Suryaman, and A. Sunarya, "Smart Contract Innovation and Blockchain-Based Tokenization in Higher Education," *J. Educ. Technol.*, vol. 5, no. 4, pp. 636–644, 2021.

[37] S. Wu, Y. Chen, Q. Wang, M. Li, C. Wang, and X. Luo, "CReam: A smart contract enabled collusion-resistant e-auction," *IEEE Trans. Inf. Forensics Secur.*, vol. 14, no. 7, pp. 1687–1701, 2018.

[38] N. Lu, B. Wang, Y. Zhang, W. Shi, and C. Esposito, "NeuCheck: A more practical Ethereum smart contract security analysis tool," *Softw. Pract. Exp.*, vol. 51, no. 10, pp. 2065–2084, 2021.

[39] S. K. Mariniharsi, T. Hidayati, and I. Tricahyadinata, "Pengaruh karakteristik individu dan karakteristik pekerjaan terhadap kepuasan kerja serta kinerja pegawai negeri sipil," *J. Ilmu Manaj. Mulawarman*, vol. 4, no. 1, 2020.

[40] R. Casado-Vara, A. González-Briones, J. Prieto, and J. M. Corchado, "Smart contract for monitoring and control of logistics activities: Pharmaceutical utilities case study," in *The 13th International Conference on Soft Computing Models in Industrial and Environmental Applications*, 2018, pp. 509–517.

[41] H. Rohaeni and N. Marwa, "Kualitas Pelayanan Terhadap Kepuasan Pelanggan," *J. Ecodemica*, vol. 2, no. 2, 2018.

[42] W. Zou *et al.*, "Smart contract development: Challenges and opportunities," *IEEE Trans. Softw. Eng.*, 2019.

[43] S. E. Chang, Y.-C. Chen, and M.-F. Lu, "Supply chain re-engineering using blockchain technology: A case of smart contract based tracking process," *Technol. Forecast. Soc. Change*, vol. 144, pp. 1–11, 2019.

[44] S. J. Pee, E. S. Kang, J. G. Song, and J. W. Jang, "Blockchain based smart energy trading platform using smart contract," in *2019 International Conference on Artificial Intelligence in Information and Communication (ICAIIC)*, 2019, pp. 322–325.

[45] P. Praitheeshan, L. Pan, J. Yu, J. Liu, and R. Doss, "Security analysis methods on ethereum smart contract vulnerabilities: a survey," *arXiv Prepr. arXiv1908.08605*, 2019.

[46] A. H. L. Luu, D.-H. Chu, H. Olickel, P. Saxena, "No Title," *Mak. smart Contract. smarter, ACMSIGSAC Conf. Comput. Commun. Secur.*, 2016, [Online]. Available: https://dl.acm.org/doi/abs/10.1145/2976749.2978309?casa_token=1Ft8l2nWaBwAAAAA%3A5A82niMloDGIY4osmaR06Kn9ybySHfyjzbpdveTxd51msuo37nSAhWVRqThD_w_OrbSo8qyS7VQ.

[47] M. Giancaspro, "Is a 'smart contract'really a smart idea? Insights from a legal perspective," *Comput. law Secur. Rev.*, vol. 33, no. 6, pp. 825–835, 2017.

[48] F. R. K. Husada, "PERANCANGAN SISTEM PERBELANJAAN ONLINE BERBASIS WEB MENGGUNAKAN METODE V-MODEL," *Peranc. Sist. Perbelanj. ONLINE Berbas. WEB MENGGUNAKAN Metod. V-MODEL*, vol. 8, no. 5, p. 55, 2019.

[49] H. Liu, Y. Zhang, S. Zheng, and Y. Li, "Electric vehicle power trading mechanism based on blockchain and smart contract in V2G network," *IEEE Access*, vol. 7, pp. 160546–160558, 2019.

[50] U. F. Ubaidillah and H. Murti, "Implementasi Sistem Informasi Pengolahan Data Menggunakan Teknologi Blockchain Pada : Data Kabupaten Kota Kendal," *Jusikom J. Sist. Komput. Musirawas*, vol. 6, no. 1, pp. 41–49, 2021, doi: 10.32767/jusikom.v6i1.1274.

[51] L. Yu, W.-T. Tsai, G. Li, Y. Yao, C. Hu, and E. Deng, "Smart-contract execution with concurrent

block building," in *2017 IEEE Symposium on Service-Oriented System Engineering (SOSE)*, 2017, pp. 160–167.

[52] Y. Zhang, S. Kasahara, Y. Shen, X. Jiang, and J. Wan, "Smart contract-based access control for the internet of things," *IEEE Internet Things J.*, vol. 6, no. 2, pp. 1594–1605, 2018.

[53] G. D. Putra, S. Sumaryono, and W. Widyawan, "Rancang Bangun Identity and Access Management IoT Berbasis KSI dan Permissioned Blockchain," *J. Nas. Tek. Elektro dan Teknol. Inf.*, vol. 7, no. 4, pp. 384–390, 2018, doi: 10.22146/jnteti.v7i4.455.

[54] L. Thomas, Y. Zhou, C. Long, J. Wu, and N. Jenkins, "A general form of smart contract for decentralized energy systems management," *Nat. Energy*, vol. 4, no. 2, pp. 140–149, 2019.

[55] Y. Li, W. Yang, P. He, C. Chen, and X. Wang, "Design and management of a distributed hybrid energy system through smart contract and blockchain," *Appl. Energy*, vol. 248, pp. 390–405, 2019.