Harnessing Blockchain in BPS-Statistics Indonesia Microdata Dissemination: A Case Study of Microdata Tracking Mechanism

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Abstract. Towards achieving BPS-Statistics Indonesia missions, the dissemination process of statistical products must be carried out well. One of BPS-Statistics Indonesia statistical products is the microdata. In this case, the activity of disseminating microdata should be conducted through the implementation of feasible best practices. Related to that, in a fast-paced of the ever-changing world that heavily relies on the evolution of technology, the process of bringing out the best efforts in disseminating microdata must as well follow the rhythm of the moving technology to meet the current needs of the digital society, because otherwise it will be obsolete as time goes by. One of the important issues is the limitation of the existing system in tracking microdata to ensure its authenticity and integrity, in case where the users have purchased the microdata from BPS-Statistics Indonesia. In addressing this traceability issue, a solution through the implementation of the cutting-edge Blockchain technology is considered. A design is proposed to incorporate Blockchain into the existing mechanism of BPS-Statistics Indonesia microdata dissemination. Therefore, a system architecture and a schema for smart contract utilization are proposed to reinforce the microdata tracking.

1. Introduction

In supporting the role of BPS-Statistics Indonesia as the National Statistical Office (NSO) of Indonesia along with its vision as the "Provider of Qualified Statistical Data for Advanced Indonesia", incorporating state-of-the-art best practices and innovative ways to do BPS-Statistics Indonesia duties is indeed an important step towards achieving the goals. In line with the vision [1], BPS-Statistics Indonesia has stipulated its missions accordingly, one of them is to conduct excellent services in the field of statistics for the development of National Statistical System. In conducting excellent services [2], public satisfaction is a main purpose. This kind of public satisfaction can be accomplished if the services given are carried out based on a certain predetermined service standards. Service standards can be defined as a set of established measures to standardize a good services, which also consider the quality standards aspect.

The process of conducting excellent service itself is closely related to the dissemination process of BPS-Statistics Indonesia statistical products. Hence, to ensure the delivery of excellent service to the data users, we must ensure the quality of statistical dissemination [3]. In this context, dissemination is defined as the act of spreading information or knowledge so that it reaches many people [4]. The dissemination processes must comply with international standards, such as the United Nations Fundamental Principles of Official Statistics (UNFPOS). One of the principles states that "to retain trust in official statistics, the statistical agencies need to decide according to strictly professional considerations, including scientific principles and professional ethics, on the methods and procedures for the collection, processing, storage, and presentation of statistical data" [5]. The presentation aspect here is highly associated with statistical dissemination.

In line with that, according to the Generic Statistical Business Process Model (GSBPM) [6], which describes and defines the set of business processes needed to produce official statistics, 'disseminate' phase is a phase that manages the release of the statistical products to users, including all activities associated with assembling and releasing a range of static and dynamic products via a range of channels. Dissemination activities support users to access and use the products released by the statistical organization. The GSBPM itself provides a standard framework and harmonized terminology to help statistical organizations to modernize their statistical production processes, as well as to share methods and components.

In relevance to that, there are many statistical products that have been produced by BPS-Statistics Indonesia, one of them is the microdata. Microdata [7] is the data regarding characteristics of a population unit, which is collected through census, survey, administration product compilation activity, and/or by other means according to the development of knowledge and technology. For instances, the microdata of Village Potential Data Collection (Podes), National Socio-Economic Survey (Susenas), National Labor Force Survey (Sakernas) and many others.

Concerning the current microdata dissemination process in BPS-Statistics Indonesia, an application system has been implemented to manage the transactions of BPS-Statistics Indonesia services offered to data users, including transactions for microdata service, namely Silastik (Sistem Informasi Layanan Statistik). Specifically, in documenting the transactions of microdata service, Silastik has performed well in allowing faster, more accountable, and more transparent services to data users. However, Silastik has not covered the aspect of microdata traceability once the microdata is purchased by the users. This traceability aspect is intended to ensure that the users will not violate the rules as stated in the Letter of Agreement of Data Use (LADU). LADU is one of the administrative requirements a user must fulfill in order to proceed with a microdata purchase transaction [8,9]. The overall business process of microdata dissemination will further be explained in Subsection 2.1.

To maintain the integrity of the terms and conditions stipulated in LADU, a robust tracking mechanism for the microdata purchased by the users must be adopted. In this case, a mutually trusted relation between the data producer and the data user may be leveraged. From the data producer's perspective (in this case is BPS-Statistics Indonesia), they can track that a user purchasing the microdata will only use the microdata for a specific research purpose stated in the inception stage of microdata purchase transaction (which is confined for the statistical purposes only), proven with the submission of research report by the user. Meanwhile, from the data user side, they can ensure that the purchased microdata from BPS-Statistics Indonesia is the official and valid ones.

There are several alternatives that can be used to track microdata. The mechanisms that may be used including the digital signatures, timestamps and metadata analysis, blockchain technology and trusted sources. Timestamps and metadata analysis [10] is a manual way and not be possibly applied in an electronic ecosystem of data services. Otherwise, digital signatures, blockchain, and trusted sources are technology based which may be adopted for the electronic data services [11]. However, concerning the aspect of data reliability, the digital signature and trusted sources alternatives are all centered-based solutions which still bear a possibility for data producers to manipulate their previously released data, thus there is a risk of 'data fraud' here [12]. Therefore, considering all the possibilities for microdata tracking alternatives, we propose the use of blockchain to prove the authenticity and legitimacy of data [13]. Moreover, blockchain is a digital ledger or record-keeping system that stores information. It is a chain of digital blocks, where each block contains data, and once a block is added, it's very difficult to change the information in it (which will be elaborated in Section 3). In this regard, the cutting-edge technology of blockchain will be proposed as a solution to be adopted into the current business process of microdata dissemination in BPS-Statistics Indonesia, due to its powerful capabilities to handle tracking.

2. Current Business Process and Research Methodology

2.1. Current Business Process of Microdata Dissemination

The enforcement of Integrated Statistical Service Standards in BPS-Statistics Indonesia is the concrete implementation of the duties and functions of BPS-Statistics Indonesia, whether conducted on-site or online. Microdata service through the direct visit mechanism to BPS-Statistics Indonesia office (on-site) only covers the full set of microdata (without the selection of specific regions and/or variables). Meanwhile, online service covers the non-full set version of microdata, which is generally conducted in three scenarios. The three scenarios for microdata service are full regions but non-full variables, non-full regions but full variables, and both non-full regions and variables. Through the online service (Silastik), users will be served for a maximum of 10 days (working days) according to the current standard operating procedures, which is counted after the request generated by the user is clear and all the requirements needed in submitting a request are complete. Here in the service delivery component, users must agree with the terms and conditions for the microdata service. Several things to be agreed by the user before proceeding with a data request are the provision/submission of proposed data usage abstract, mandatory submission of LADU, data format, price, and media for data delivery [9].

Regarding LADU, there are clauses that specify the requirements a user must obey. Some of the clauses oblige a user to be the end user of the data so that they must not make any copies for the needs of other people or organizations, also that the user will use data records merely for research and analysis purposes, as well as the responsibility to submit their research results to BPS-Statistics Indonesia. With the current system (Silastik), BPS-Statistics Indonesia is still unable to trace whether the microdata used in research published by a group or individual is an authentic product, in this context we define authentic from the perspective in which the user formally purchased the data from BPS-Statistics Indonesia as the trusted origin source of the microdata itself. Thus, if microdata is used in research but the author (group or individual) has not had any historical transactions recorded in Silastik, then the authenticity of the microdata used in the research is doubted. It has been a big challenge to formulate the right tracking mechanism for the disseminated microdata.

2.2. Research Methodology

Since blockchain is a nascent technology, there are basic concepts and mechanisms about it that we have to understand at first in order to seize important aspects in designing the proposed architecture which incorporates blockchain into the existing mechanism of BPS-Statistics Indonesia microdata dissemination process. Hence, in composing this paper, we use the literature research methodology, which aims to grasp views and knowledge from relevant researches as well as scientific developments, also to comprehend the achievements of the predecessors' results and the progress made by other researchers. Literature research methodology is to read through, analyze and sort literature in order to identify the essential attribute of materials [14].

3. Concepts of Blockchain (Literature Study)

3.1. Definition of Blockchain

Initially, blockchain was a term used in computer science which described the structure and mechanism of data sharing. To date, blockchain is being echoed as the "fifth revolution" in computing. Blockchain is a trending approach towards distributed databases. In this case, blockchain may be regarded as a distributed database that allows control from a group of independent individuals that store and share information. Blockchain leverages the cryptographic technique to enable every individual in the network (peer-to-peer system) to manage a ledger (record of transactions) securely without the need of a third or middle party who governs rules in a system [15].

Blockchain is a technology that implements the concept of distributed digital ledger, resistance to damage, and usually without involving a central authority as controller. Basically, blockchain enables a community of users to store transactions in the form of a shared digital ledger, in which there will be no transactions that can be altered in a normal operation of the blockchain network once the transaction has been published [16]. Blockchain is a decentralized database composed of sequential and connected blocks (using the cryptographic technique) of the asset transactions which are digitally signed, as well as managed by a specific consensus model. In a nutshell, there are four basic characteristics of blockchain: immutable, decentralized, consensus driven, and transparent [17]. The four characteristics are explained below.

- *Immutable*: when a block is added, changes can't be executed for a permanent record has been created of the corresponding transactions.
- *Decentralized*: blockchain is stored in a file which can be accessed and shared by nodes in the blockchain network.
- *Consensus driven*: every block is verified independently by each node in the network through a consensus mechanism along with the stipulated rules.
- *Transparent*: in public blockchain, any parties can access and audit the complete transactions history due to its openness.

Related to its characteristics specified above, blockchain technology is composed of three main parts, they are the block, the chain, and the network. The block in a blockchain holds a list of transactions that are recorded in the ledger for a certain period of time. Its size, period, and triggering event to create a block differ for every blockchain network. For the chain, it is a hash that connects one block to another, mathematically 'chained' the blocks to become one unity. The hash for a block is created by using the data from the previous block and is often known as the fingerprint of data. While for the network, it consists of a collection of full nodes, where every single node in a network is executing the specific algorithm to secure the network and each of them has the complete database of all transactions that ever happened [15,18].

3.2. Smart Contract

Smart contracts are autonomous programs that reside on the blockchain network and encapsulate the business logic and code needed to execute a required function when certain conditions are met. Smart contracts can be programmed to perform any actions that blockchain users need and according to their specific business requirements. Properties of the smart contract are [19]:

- *Automatically executable*: it is self-executable on a blockchain without requiring any intervention.
- *Enforceable*: all contract conditions are enforced automatically.
- *Secure*: smart contracts are tamper-proof and run with security guarantees.
- *Deterministic*: a feature that ensures smart contracts to always produce the same output for a specific input.
- *Semantically sound*: complete and meaningful to both people and computers.
- *Unstoppable*: adversaries or unfavorable conditions cannot negatively affect the execution of a smart contract.

Simply put, a smart contract is an agreement or set of rules that govern a business transaction, stored on the blockchain, and is executed automatically as part of transactions. Smart contract eliminates the hassles and delays inherent in contracts by building the contract into the transaction [20]. As the volume of blockchain data continues to grow in tandem with the number of transactions, the time has come to provide truly scalable storage for smart contracts. Individuals interested in creating smart contract solutions should consider the cost of development, as well as what can and cannot be done. That is due to the irreversible nature of a smart contract, in which once a smart contract has been integrated into a blockchain, there is no straightforward way to fix any bugs that may have been introduced during the development process. As a result, a process for updating and terminating the contract status must be developed [21].

3.3. Non-Fungible Token (NFT)

Non-fungible Token (NFT) is unique and non-exchangeable crypto tokens. It's stored in a blockchain ledger to certify the authenticity of digital assets. Fungible means that each NFT token is unique and cannot be replaced with another because there are no identical aspects between one NFT and the others. Otherwise, fungible means can be easily replaced with another identical thing, not unique [22]. For instance, the Indonesia Rupiah is fungible because any person can easily exchange their Rp100.000, with another Rp100.000, they don't need to see the uniqueness of their rupiahs, Rp100.000 is Rp100.000, although it can be in various form. Vice versa, an example of fungible is the Monalisa painting. There are many copies of Monalisa Painting in the world but only one is the original, only one is painted by Leonardo Da Vinci, and it can't be replaced with something that looks the same as the original one.

NFT became popular in 2021 along with the growth of blockchain technology. It is widely known as digital art that has value. With the development of blockchain technology itself, the NFT use case extends not only to digital art, but also to ticketing, digital identity, land certificates, medical records, etc. All the things that need authenticity can be implemented through NFT as a certificate of authority.

Related to the NFT ecosystem, several protocols have been developed to settle proper standards for managing the basic functionalities of NFT. In this section, we would like to briefly mention the ERC721 (ERC stands for Ethereum Request for Comment) protocol. ERC721 is the first formal NFT standard that has been adopted widely which defines a set of code rules for the recording of NFT-related information [23]. ERC721 token is unique and can have different value than another token from the same smart contract, due to its age, rarity, or even something else like its visuals [24]. It allows the implementation of a standard API for NFT within a smart contract. In this case, ERC721 will be specifically suggested as the NFT protocol in our proposal for the smart contract schema in microdata tracking.

3.4. Web3 and Web3 Wallet

With blockchain massive developments, the internet is also evolving with the presence of Web3. Web3 is a web that implements blockchain technology [25]. Web3 has a few core principles like decentralization, permissionless, native payments, and trustless [26]. The potential impact of Web3 technologies is endless, it can transform finance (DeFi), transforming ownership (NFT), transforming payments, etc.

Web3 wallet is a digital wallet with a unique identifier for users to send and receive assets. Web3 wallet has a fixed number of character addresses generated from a pair of public key and private key [22]. Using the Web3 wallet, people can access and connect to the blockchain networks, as well as conduct a transaction and receive digital assets like NFT.

3.5. Benefits and Limitations of Blockchain

Touted as the state-of-the-art technology, blockchain has several powerful eminences in today's computing world. Some of its benefits are decentralization, transparency, immutability, high availability, highly secure, and cost saving. In the decentralization aspect, there is no need for a trusted third party or intermediary to validate transactions but instead relying on consensus of the network. For the transparency aspect, everyone can see what is on the blockchain and as a result trust is established. Then, the immutability comes from the fact that changing written data is very challenging and nearly impossible. At the same time, blockchain also demonstrates high availability due to thousands of participating nodes in a peer-to-peer network, where the data is replicated and updated on every node, enabling the network as whole to continue working even if some nodes leave or become inaccessible. In addition, blockchain is highly secure because all transactions on a blockchain are cryptographically secured (verified based on a predetermined set of rules) and thus provide network integrity. Besides, blockchain is also cost saving from the point that it eliminates overhead costs in the form of fees which are usually paid to the third party. Few other benefits of the blockchain are the simplification of the current paradigm (serve as a shared ledger), faster dealings, platform for smart contracts, as well as facilitating smart property.

However, just like any other new emerging technologies, blockchain is also dealing with some sort of challenges that need to be addressed. The first limitation of blockchain is the scalability, in which current blockchain networks are not actually as scalable as it may be regarded. Furthermore, the adoption aspect is also an issue where blockchain technology is still considered as a nascent technology, thus there is still a long way to go before the mass adoption of it. The other challenge is the regulation, in which due to its decentralized nature, regulation is almost impossible on blockchain since there is no such regulatory authority as to whom the responsibility is placed upon in case if something goes wrong along the way. Moreover, there is also an issue regarding privacy and confidentiality (in public blockchain) in the context that for many industries such as financial, law, or medical sectors, this kind of transparency is not really desirable [19].

4. Blockchain Usage and Application of NFT in Microdata Dissemination (Discussion)

Based on the current problem for the microdata dissemination in BPS-Statistics Indonesia, NFT and blockchain may be an effective solution to solve the problem of tracking microdata authenticity in its usages. We also propose extending the scope of the current system (Silastik) accordingly so that it can address the issue.

4.1. Proposed System Architecture

In this subsection, we present the proposed system architecture that utilizes blockchain technology, as illustrated in figure 1.

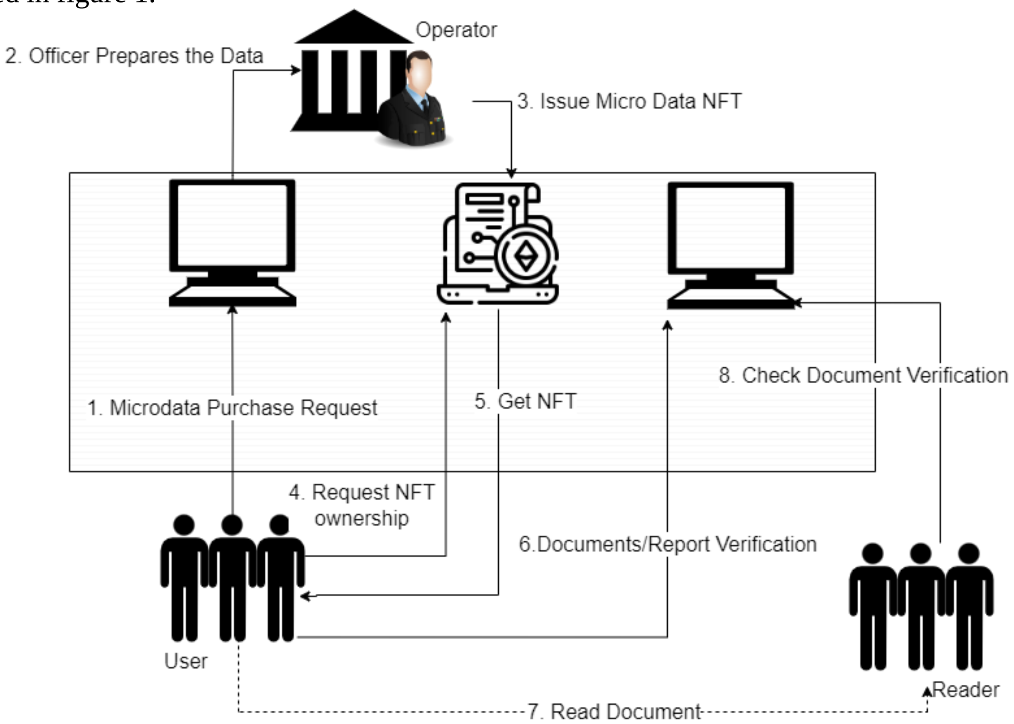

Figure 1. Flow diagram of proposed system.

Regarding the proposed system architecture in figure 1, (1) when users request to purchase microdata, they fill in the request form and complete the requirements needed by the system (Silastik). (2) The operator is delegated by the system to process the request as well as prepare the data, but a more detailed procedure for buying microdata is not covered in this diagram. (3) After the preparation of the requested data is done, the operator mints (the process of creating assets as an NFT) the microdata as an NFT. (4) When the minting process is done, user can request NFT ownership in the system and get the NFT (5). Outside the system, users use their purchased microdata to compile a report, do research, analyses, etc. In this case, the product (document report/research result) of microdata usage must be reported to BPS-Statistics Indonesia to get verification as stated in LADU clause (6). Verification process could be done automatically using blockchain technology, and after the document is verified, then the system will publish it in a list, so the public will be able to know whether the produced documents are using official microdata from BPS-Statistics Indonesia or not.

4.2. Proposed NFT Schema, Minting Process and Ownership Transfer

4.2.1. Metadata Schema. According to the ERC721 standard, we define a microdata metadata JSON (JavaScript Object Notation) schema. The proposed schema stores the attributes of microdata such as publisher, microdata name, microdata issue date, microdata URI, and hash containing user data.

```
{
  "title": "Microdata Metadata",
  "properties" : {
    "microdata_publisher": String,
    "microdata_name":String,
    "microdata_issue_date":String,
    "microdata_URI": String,
    "hash": SHA256
  }
}
```

Figure 2. Microdata metadata JSON schema.

The *microdata_publisher* property contains the name of the publisher of microdata (Badan Pusat Statistik); *microdata_name* contains the name of the microdata asset used as an NFT or the name of the microdata purchased by the user; *microdata_issue_date* contains the NFT metadata creation timestamp; *microdata_URI* contains the link to where the purchased microdata asset is located or stored. figure 2 shows us that there is also a hash property in the form of SHA256 containing the information from the user which has been previously encrypted using SHA256. The encrypted user information has a standard structure as shown in figure 3.

```
"username" : String,
"address" : String,
"institution" : String,
"email": String,
"transaction_id": String,
```

Figure 3. Format of user information for encryption.

Data with a structure as shown in figure 3 will be encrypted using SHA256, thus later it can be used to verify microdata usage report.

4.2.2. Minting Process and Ownership Transfer. In this subsection, a proposed process for minting and transferring NFT ownership is presented in figure 4.

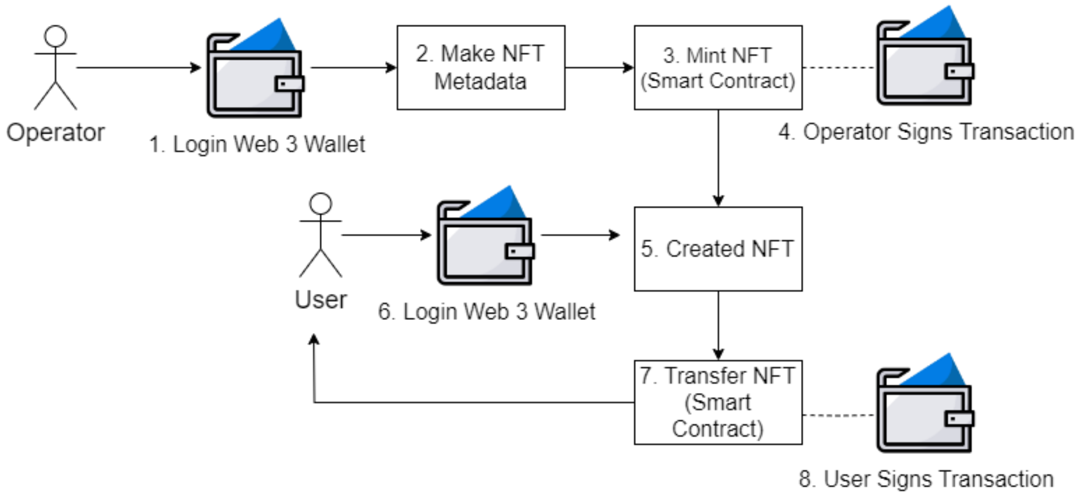

Figure 4. Flow diagram of minting process and ownership transfer.

The operator starts the minting process along with the microdata transaction verification process in the system. The minting process starts when the operator login to Web 3 Wallet to connect to the blockchain (1). (2) The operator issues Microdata Metadata with an example as shown in figure 5.


```json
{
  "title": "Microdata Metadata",
  "properties": {
    "microdata_publisher": "Badan Pusat Statistik",
    "microdata_name": "SUSENAS Maret 2023",
    "microdata_issue_date": "2023-09-01T10:47:08.374499",
    "microdata_uri": "https://transdata-cloud.bps.go.id/index.php/s/3j2KHnAe44S4RwX",
    "hash": "bf8f9801f7f909918e0959e8374a8fc2de84ac147914868e26697ca77dce9def"
  }
}
```


Figure 5. Sample microdata metadata JSON schema.

(3) BPS sends the JSON schema to the Blockchain to be executed by an existing smart contract. Smart contract is executed when the operator performs a sign for the transaction using his wallet, resulting in NFT (4). (5) The created NFT has attributes as shown in figure 6.


```json
{
  "title": "Microdata Metadata",
  "properties": {…},
  "owner":{
    "address":"0x0000000000000000000000000000000000000000"
  },
  "creator":{
    "address":"0xC29c94fcA5d6A5CCBC377006fED8be185d163661"
  }
}
```


Figure 6. NFT microdata metadata JSON schema after the minting process.

When the NFT has been successfully created by BPS, the owner address of the NFT is still filled with **0x00…** because it hasn't been processed (claimed) by the user. (6) In order for a user to have the purchased NFT microdata, the user is required to be connected to their Web 3 wallet to be able to interact with the created NFT. (7) When the smart contract for NFT transfers is executed, (8) user needs to sign the transaction to trigger the smart contract. The NFT that has been transferred to the user has attributes as shown in figure 7.


```
{
  "title": "Microdata Metadata",
  "properties": {...},
  "owner":{
    "address":"0xCf3727C2a6033f5D864e04a5D766CB3577396aE8"
  },
  "creator":{
    "address":"0xC29c94fcA5d6A5CCBC377006fED8be185d163661"
  }
}
```


Figure 7. NFT microdata metadata JSON schema after ownership transfer.

Figure 7 shows that NFT ownership has been transferred to the user which can be seen from the filled owner address. Ownership of this NFT is authentic proof that the user has purchased microdata officially from BPS-Statistics Indonesia. This NFT will be useful for verifying the report that will be made later.

4.2.3. Verification Process. To verify the report created by the user, they need to fill in the microdata usage report form. The proposed mechanism for filling out the report form so that it can be used for verification is shown in figure 8.

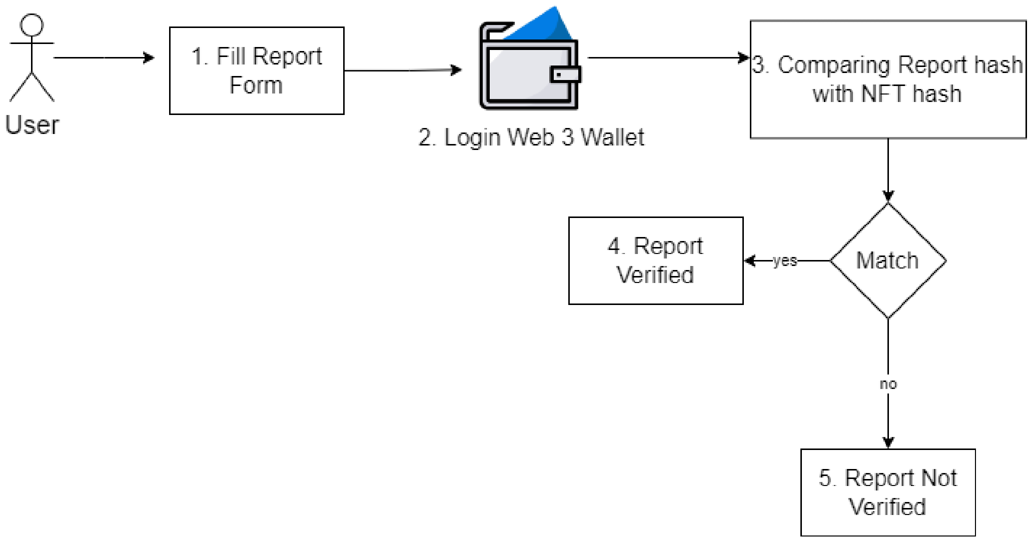

Figure 8. Flow diagram of report verification.

(1) The user fills out the report form in the system, the user needs to fill in the report name along with the transaction ID when purchasing microdata. (2) To get a list of NFTs owned by the user, the user needs to login to his Web 3 Wallet. (3) The system then forms a data structure based on user information and transaction ID, which will then be hashed using SHA256.


```
"username":"Dea Venditama",
"address":"Bekasi",
"institution":"Dea's company",
"email":"deavenditama@gmail.com",
"transaction_id":4514
```


Figure 9. Format of user information for encryption.

After hashing the information from the user using SHA256, it will produce a hash output as shown in figure 10.

```
bf8f9801f7f909918e0959e8374a8fc2de84ac147914868e26697ca77dce9def
```

Figure 10. Hash signature calculated from user data and transaction ID.

If the hash generated is the same as one of the NFT hashes owned by the user, then the report submitted by the user is declared valid (4) and vice versa (5).

Through the proposed mechanism, every user that does not verify their report or document in the system, can be blacklisted from the system to a certain extent in which for example if they are not submitting any reports or research results consecutively for a certain number of served transactions (suppose 2 or 3 times, subject to internal policy), then they will not be able to get or request another microdata from BPS-Statistics Indonesia in the future. This is because they simply deviate from the clause in LADU. In this case, verified reports could be used as a reference list to see whether a report used legally obtained data from BPS-Statistics Indonesia or not. If a report is not included in the list even though it used or cited BPS-Statistics Indonesia data, then the quality of the report is doubtful, due to the issue of data authenticity.

Meanwhile, from the user's point of view, they can confirm that the data they purchased is the correct ones and verified by BPS-Statistics Indonesia. In case a system error occurs at any time or there is a revision that causes the microdata to change, then the user will be able to prove that the data he had was valid at a certain point of time. In addition, from the perspective of the data provider (BPS-Statistics Indonesia), they can track data usages. Data providers can see the number of times a data is used and the usefulness of the data itself. By having this kind of information, the data provider may carry out further analysis regarding which data is widely used and needed by users. This information may derive further improvement to the quality of BPS-Statistics Indonesia data.

5. Conclusion

From the discussion and proposed design elaborated in previous sections of this paper, the following conclusions can be drawn.

1) The application of blockchain, especially NFT, can be an effective solution to the problem of microdata traceability.
2) Microdata that is converted into NFT can be used to verify the results of microdata processing.
3) The authenticity and legality of microdata can be proven using NFT.
4) BPS-Statistics Indonesia can evaluate users who comply with LADU requirements.

6. Suggestions and Way Forward

Based on the discussion points explained regarding the proposed architecture of a blockchain-based system in developing microdata tracking mechanism, the following are our suggestions for further development.

1) Designing business processes that are more detailed about applying blockchain to microdata.
2) Conducting further comparison study about the types of blockchain that may be suitable for the implementation in the government environment, specifically for microdata dissemination process.
3) Looking for a method to verify research results or reports published using BPS-Statistics Indonesia microdata, to check if the microdata was obtained officially or not. This is necessary to assess the quality of a research result or report that has been made, in other words determining whether the research result or report used true and valid data.
4) Blockchain has a possibility to also be applied in other BPS-Statistics Indonesia's products such as tables on the website, publications (e-books), and press release reports (known as Berita Resmi Statistik). In addition, blockchain can be combined with big data analysis to produce insights regarding the use of BPS-Statistics Indonesia data. However, this will need a series of in-depth analyses and further discussions with the corresponding subject matters.

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