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Blockchain Implementation on Subsidised LPG Distribution in Gas Supply Chain (Case Study: Medan)

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ABSTRACT
This article explores the potential of private blockchain technology on the multichain platform for the implementation of subsidised lpg distribution information systems in Medan. The aim is to improve transparency, security and reliability. Data was collected through literature review and documentation analysis, and the system was developed using a waterfall methodology. The multichain-based architecture ensures secure, transparent and traceable transactions, thereby reducing the incidence of fraud and discrepancies. The results show that the architecture meets the necessary criteria for building a robust framework for gas distribution. This validates the effectiveness of the Multichain-based private blockchain in improving the efficiency and reliability of the subsidised gas distribution system in Medan.
Keyword: Blockchain, LPG, Medan, Subsidies, Supply Chain

ABSTRAK
Pada Article ini dilakukan penelitian terkait potensi teknologi *private* blockchain dimana ada platform multichain sebagai implementasi sistem informasi distribusi lpg bersubsidi di Medan. Tujuannya adalah untuk meningkatkan transparansi, keamanan, dan keandalan. Data dikumpulkan melalui tinjauan literatur dan analisis dokumentasi, dan sistem dikembangkan dengan menggunakan metodologi *waterfall*. Arsitektur berbasis *multichain* memastikan transaksi yang aman, transparan, dan dapat dilacak, sehingga mengurangi kejadian penipuan dan ketidaksesuaian. Hasil penelitian menunjukkan bahwa arsitektur tersebut memenuhi kriteria yang diperlukan dalam membangun kerangka kerja yang kuat untuk distribusi gas. Hal ini memvalidasi keefektifan blockchain pribadi berbasis Multichain untuk meningkatkan efisiensi dan keandalan dalam sistem distribusi gas bersubsidi di Medan.
Kata kunci: Blockchain, LPG, Medan, Subsidi, Rantai Pasokan

1. Introduction

In the context of the current industrial revolution, the emergence of blockchain technology represents a significant advance in the field of information security and authenticity [1]. Blockchain is an information sharing system that employs a robust data transparency mechanism, enabling all participants in the system to access comprehensive information. The utilisation of blockchain technology is anticipated to facilitate the government's performance in regulating the process of distributing subsidised gas to the public [2]. The process will be made accessible to the public. Blockchain technology can be employed to access information that has previously been difficult to obtain due to various constraints [3][1].

Nevertheless, there are considerable obstacles to overcome in order to guarantee the fair and equitable distribution of subsidised LPG gas to the intended beneficiaries. As reported in the press, the distribution of subsidised 3 kg LPG gas in Medan is encountering difficulties with regard to the accuracy of targeting [4]. The local government is implementing measures to enhance the precision of the distribution process, thereby guaranteeing that the subsidy is allocated to the intended beneficiaries and preventing its misappropriation.

The current system is deficient in terms of transparency and accountability, which impedes the ability to effectively track and monitor the distribution process, resulting in inefficiencies and discrepancies in subsidy delivery [5].

In this study, the authors utilise blockchain technology for the distribution of subsidised LPG gas. The utilisation of blockchain technology in the context of subsidised LPG gas distribution is beneficial in terms of the storage of data and information pertaining to the aforementioned distribution [6]. The data and information stored about the distribution of LPG gas is useful as a source of information, allowing the distribution process to be managed effectively. In this research, the author employs a system that can provide precise information through the utilisation of an information system that incorporates blockchain technology. Furthermore, the author develops a website application that is utilised by subsidised LPG gas sub-agents for the purpose of conducting transactions [7]. Transactions can be initiated if the buyer possesses a subsidised LPG gas receiver card and has a coin allowance in his account.

In addition, the website will record the transactions of each subsidised LPG gas recipient. The researchers have also set up a website that can be visited by subsidised LPG gas recipients and that will be managed by Disperindag (*Dinas Perindustrian, Perdagangan, Koperasi, Usaha Kecil dan Menengah*). Against this background, it can be concluded that the distribution of LPG gas has not been implemented in an optimal way. This is due to the lack of an effective usage information system in terms of handling all types of data/information related to the distribution of subsidised LPG gas. In this study, the authors conducted research on the distribution of subsidised LPG gas using blockchain technology. The aim was to develop a system for the regular storage of data/information related to the distribution of subsidised LPG gas [8]. Therefore, the authors conducted research entitled Blockchain Implementation on Subsidised LPG Distribution in Gas Supply Chain (Case Study: Medan).

2. Methods

This research employs the waterfall method for software system development. This method comprises a series of sequential stages, which are outlined below.

The waterfall method, as described by [9], comprises the following steps:

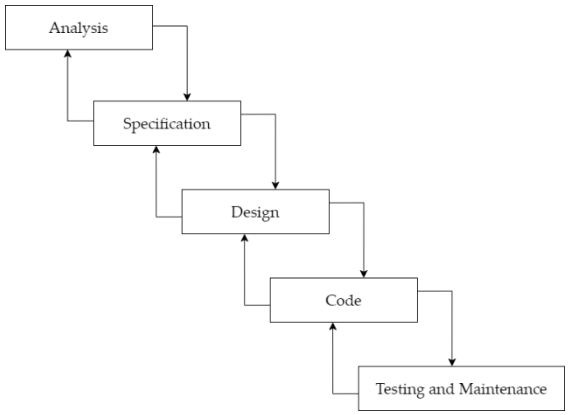

Figure 1. Waterfall Steps

1. System engineering and analysis (system engineering and analysis)

   As software is part of a larger system, the work begins with the formation of requirements for all elements of the system, and then sorting out which ones are for software development.

2. Software Requirements Analysis

   The collection of software requirements is a crucial aspect of the software development process. These requirements must be carefully documented and reviewed with the customer to ensure alignment with the desired functionality and performance.

3. Design

   The design phase is where the four key attributes of the software programme are defined. These include the data structure, software architecture, detailed procedures, and interface characteristics. The design process is responsible for transforming the requirements into the form of characteristics that the software will understand before the actual programming begins.

4. Code

The translation of the design into a form that can be understood by the machine, using a programming anguage, is the final step in the software development process. The design must be well-documented and become part of the software configuration.

5. Testing and Maintenance

The translation of the design into a form that can be understood by the machine, using a programming language. The final stage of the development cycle is maintenance. This is performed after the software is deployed and encompasses corrective, adaptive and prospective maintenance. The data collection methods employed in this research are an interview, questionnaire and documentation.

3. Results and Discussion

The proposed system is expected to provide significant benefits to various stakeholders, including the government, gas sub-agents and the community. By using blockchain technology, the system will effectively manage and store large amounts of transaction data and the identities of individuals entitled to subsidised LPG gas [10]. This efficient management of identity and transaction data is expected to facilitate the fair distribution of LPG gas to eligible recipients, thereby minimising gas shortages and preventing the confusion and protests that result.

The system overview describes the structure of the proposed system, including its procedures and steps. It details the inputs and outputs of the system and explains how it will be built and operated. This overview serves as an initial framework for the design of the system, establishing the fundamental aspects that will guide the subsequent development phases.

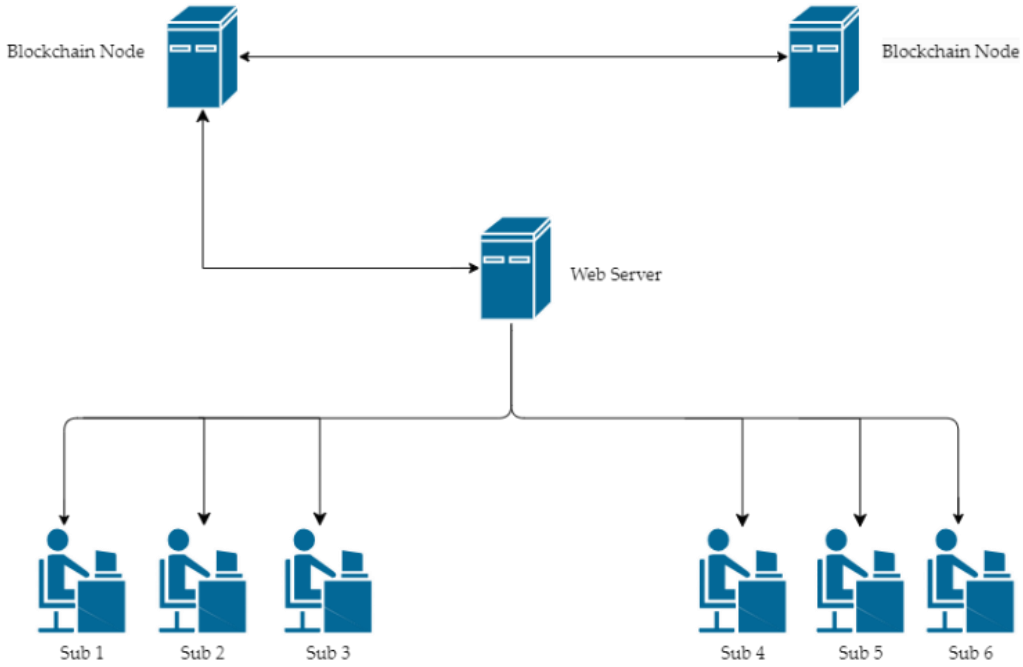

Figure 2. Blockchain Architecture

The system architecture consists of several key components, including a blockchain node, a web server, and a client computer. The client computer, used by sub-agents, facilitates gas purchase transactions by accessing a webpage hosted on the web server. All interactions between the client computer and the web server are conducted using the Hypertext Transfer Protocol (HTTP) [11]. As a centralised web application, the web server provides essential services to sub-agents and customers for the collection of gas purchase data. It also manages all operational activities and is connected to a local database that stores necessary data, such as purchase data, sub-agent details (ID, address, name, NIK, mobile number, QR code, status, user_id, count, type, password), user data (ID, address, name, NIK, mobile number, QR code, status, user_id, count, password), and other supporting information.

The blockchain node component enables API calls via the JSON RPC method. It acts as a computer within the blockchain's peer-to-peer network, facilitating the management of blockchain operations required to record gas purchase data. The web server uses JSON RPC API calls to interact with the blockchain, ensuring the accurate and secure storage of ballots generated by customers (client computers) on the blockchain. This

integration of blockchain technology ensures the integrity and transparency of transaction data within the system.

The following overview presents the workflow involved in the transaction process.

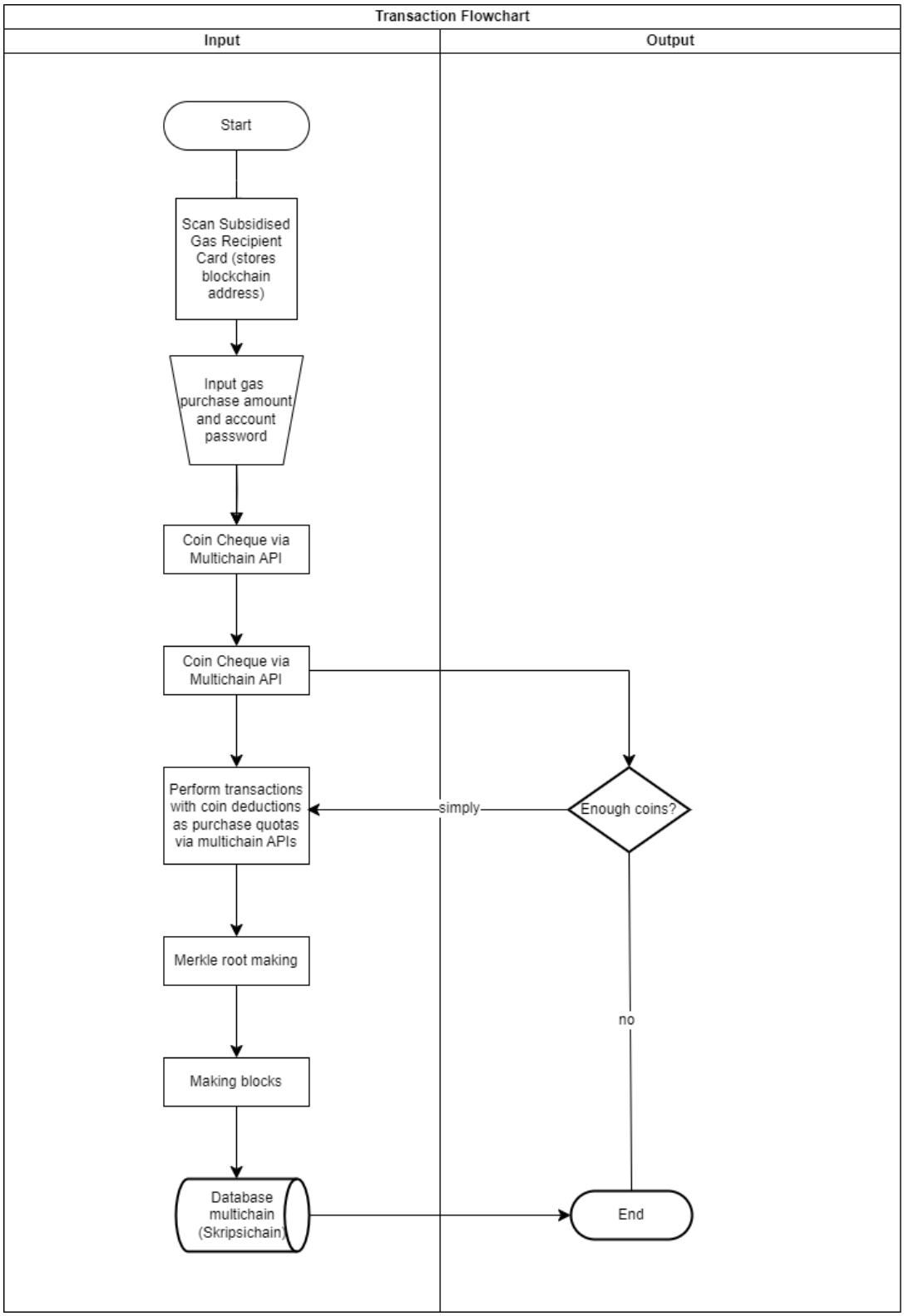

Figure 3. Transaction Flowchart

3.1 Merkle Tree

The Merkle tree was first presented by Ralph Merkle in 1979. It is a tree structure that is useful for several application areas, especially in cryptography [12]. Merkle trees have been an important key to data verification throughout the history of computers. Their structure helps verify the consistency of data content. Its

architecture helps accelerate security authentication in big data applications [13]. The Merkle tree is a resolving binary tree, with each node hashing the values of its child nodes. The structure of the Merkle tree is shown in the figure below.

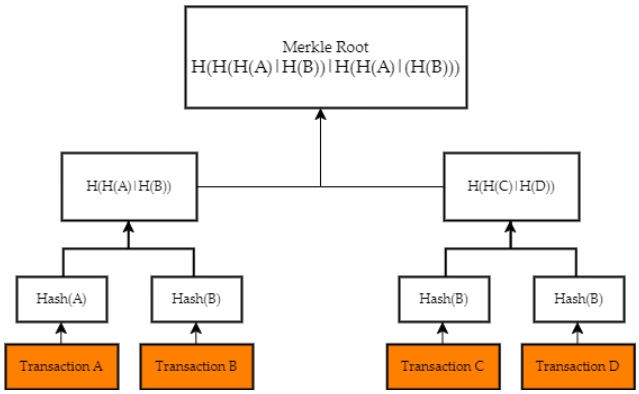

Figure 4. Merkle Root Structure

H A = SHA256(SHA256(transaction A))

H AB = SHA256(SHA256(H A + H B))

Description:

H A = Hash id of transaction A

H AB = Hash of transaction A and B combined

Transaction = Transaction data.

Once the hash result of the entire transaction has been obtained, the value of the Merkle root can be calculated by converting the hash result of the entire transaction into big-endian [14]. The merkle root is not employed for the verification of individual transactions; rather, it is utilised in the verification of a set of transactions. In the event of a change in one of the transactions, there will be a corresponding change in the root merkle. The root merkle provides evidence of which transactions are included in the block and in what order they exist. SHA-256 is a hashing algorithm that produces a digest of 256 bits and has 64 rounds.

3.2 Blocks

The formation of the header block commences with the transaction from the merkle tree process and the acquisition of the merkle root. Upon the receipt of the merkle root, the block will commence its creation. Each header block is assigned a unique hash value. The header hash is generated through the utilisation of a number of data structures, as outlined below:

Table 1. Block Header Structure Data Table

Field	Size	Data	Description
Version	4 bytes	Little-endian	Stores version information of a block
Previous Block Has	32 bytes	Little-endian	Metadata that stores the hash of the previous block
Merkle Root	32 bytes	Little-endian	The set of information from the hashed transaction
Time	4 bytes	Little-endian	stores information on when the block was created
Bits	4 bytes	Little-endian	stores information on the difficulty level of the algorithm used
Nonce	4 bytes	Little-endian	random numbers that are useful for mining

It should be noted that initially, all the data structures above are not yet in little-endian format and in version, time, bits, nonce form. If these are not in hexadecimal, they must be converted into hexadecimal numbers before being converted to little-endian. After this, the block header can be calculated as follows: SHA256 (SHA256 (version + previous block hash + merkle root + time + bits + nonce)). If the results of the SHA256 process have already been obtained, the hash is then reversed from the previous little-endian format to big-endian.

3.3 Flowmap and System Design

1. Disperindag Admin Account Creation Flowmap

The flowchart for creating a Disperindag admin account outlines the sequential steps involved in creating an admin account within the system. First, the prospective Admin accesses the registration interface where he/she is required to enter the necessary credentials and personal information, including a unique username, a secure password and relevant identification details. Once these details have been submitted, the system verifies the information provided to ensure its accuracy and authenticity. Upon successful verification, the system creates a new administrator account, assigns appropriate administrative privileges and stores the account details in the central database. This process ensures that only authorised individuals are granted administrative access, thereby maintaining the integrity and security of the system.

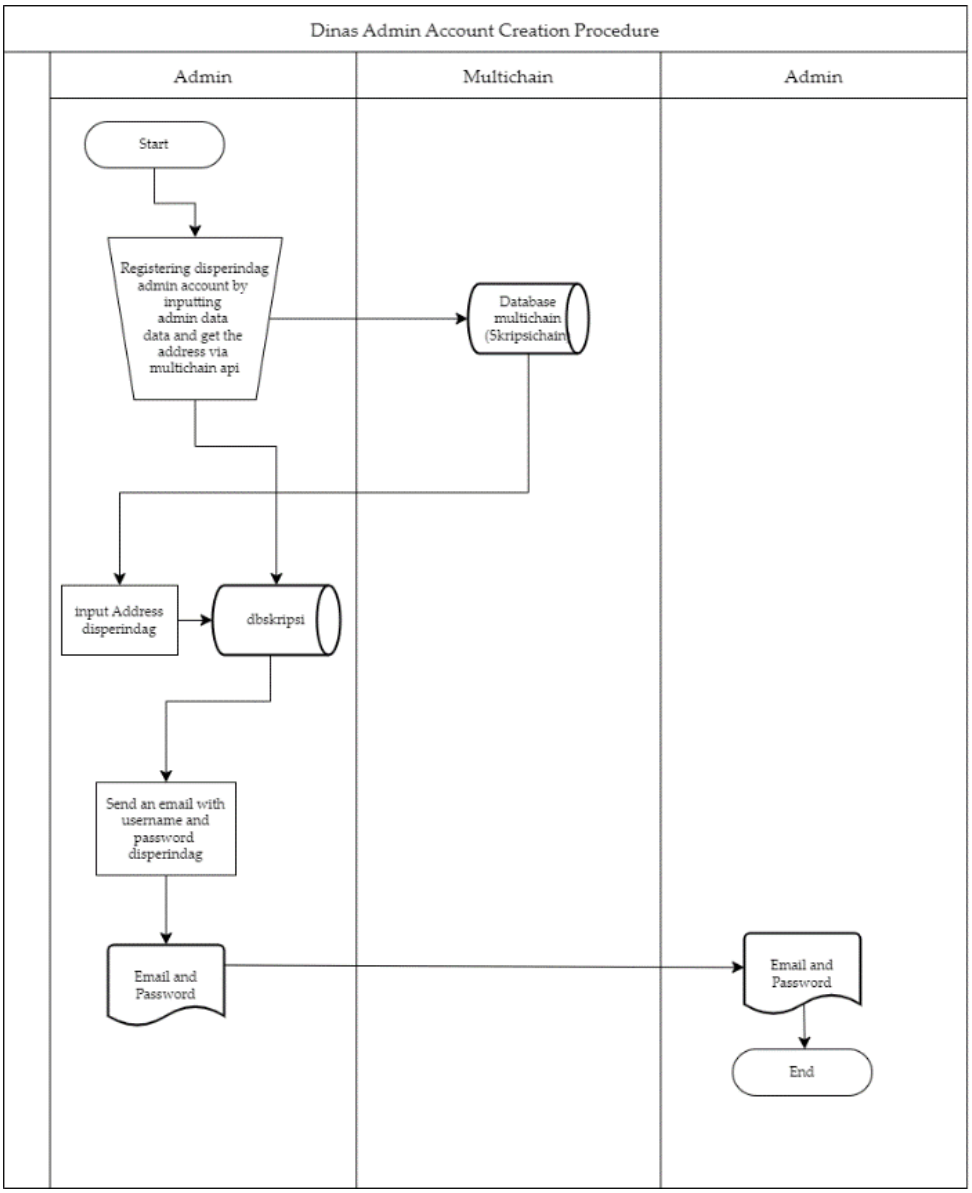

Figure 5. Disperindag Admin Account Creation Flowmap

2. Sub-Agent Account Creation Flowmap

The following flowchart illustrates the process of creating a sub-agent account using a multi-chain system, initiated by the administrator. The administrator inputs the sub-agent's details and obtains the requisite address information via the multi-chain API, which is then stored in the database. The system generates a unique address for the sub-agent, processes it through "dbskripsi", and sends an email with the username and password to the sub-agent. Finally, the sub-agent receives the email and can access their assigned credentials, thereby

completing the account creation process.

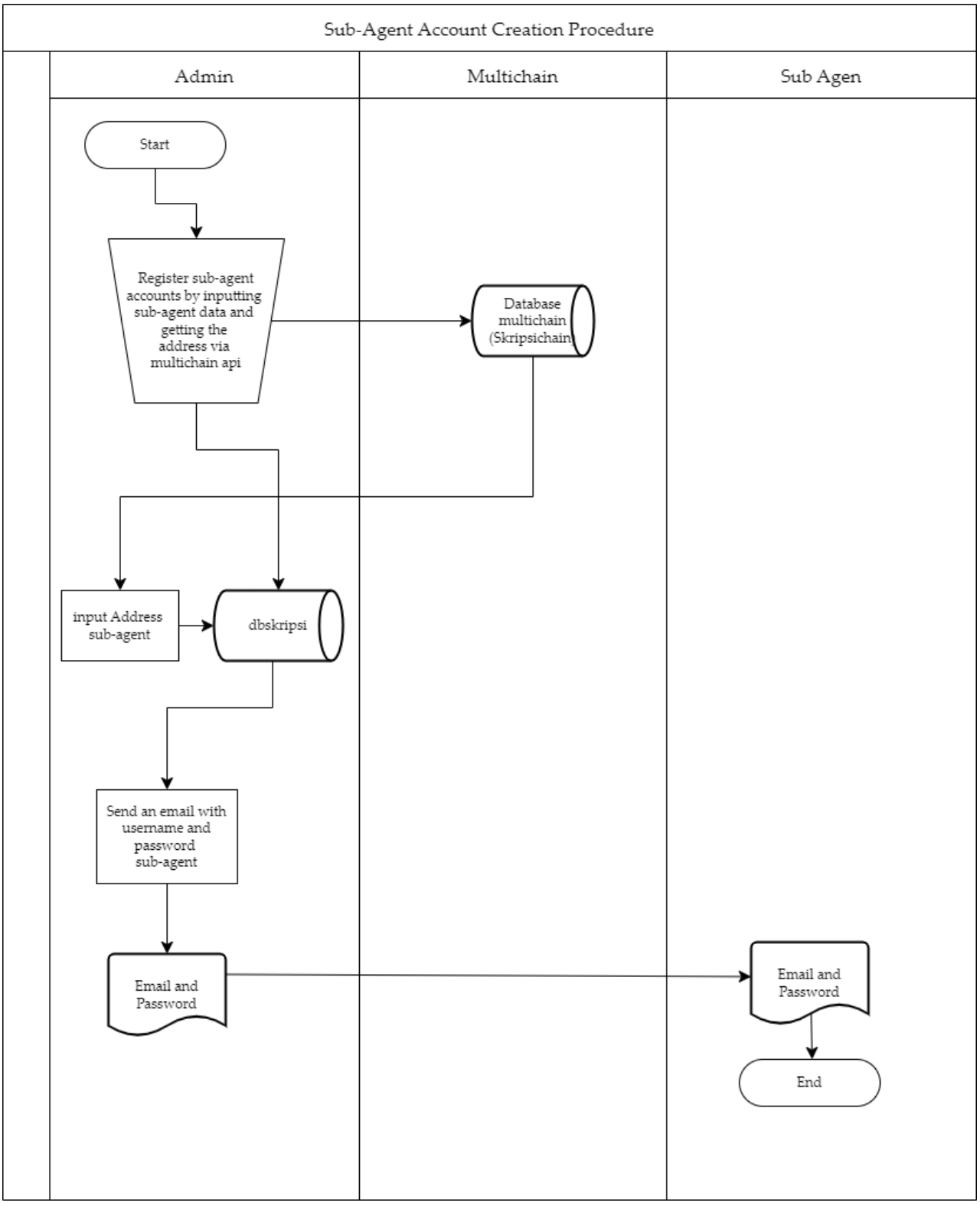

Figure 6. Flowchart Sub Agen Created Account

3. Gas Receiver Account Creation Flowchart

The image depicts the process by which a sub-agent account is created. This process is initiated by the administrator, who registers the sub-agent's details and obtains the necessary address information through the multichain API. This information is then stored in the database. Subsequently, the system generates a unique address, processes it, and transmits an email to the sub-agent containing the username and password, thereby enabling them to access their assigned credentials and complete the account creation process.

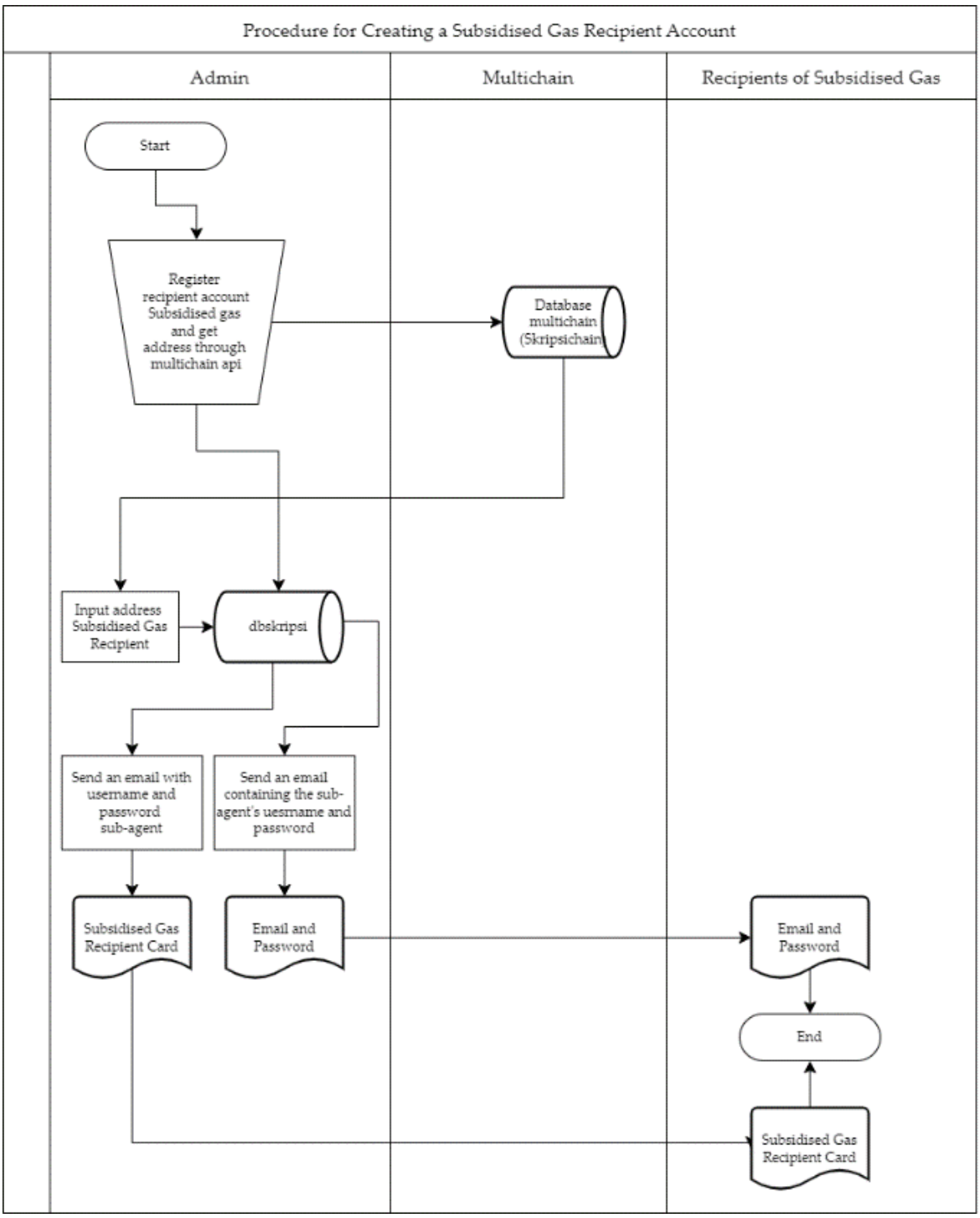

Figure 7. Flowchart Created Account Received Subsidies Gas

4. Transaction Flowmap

The image depicts the procedure for purchasing subsidized fuel in Indonesia. The process commences with the customer presenting their subsidised gas recipient card. Subsequently, the sub-agent scans the card and verifies the customer's address within the system. If the address is correct, the customer may then input the purchase amount and their account details. Subsequently, the system verifies the customer's account password. In the event that the password is valid, the transaction is processed and the customer receives their subsidised gas. Additionally, the system generates reports for the sub-agent and the Ministry of Energy and Mineral Resources. This process is designed to guarantee that subsidised gas is only accessible to eligible recipients. By utilising a card and verifying addresses, the system serves to prevent fraud and ensure that the subsidy is utilised in an effective manner.

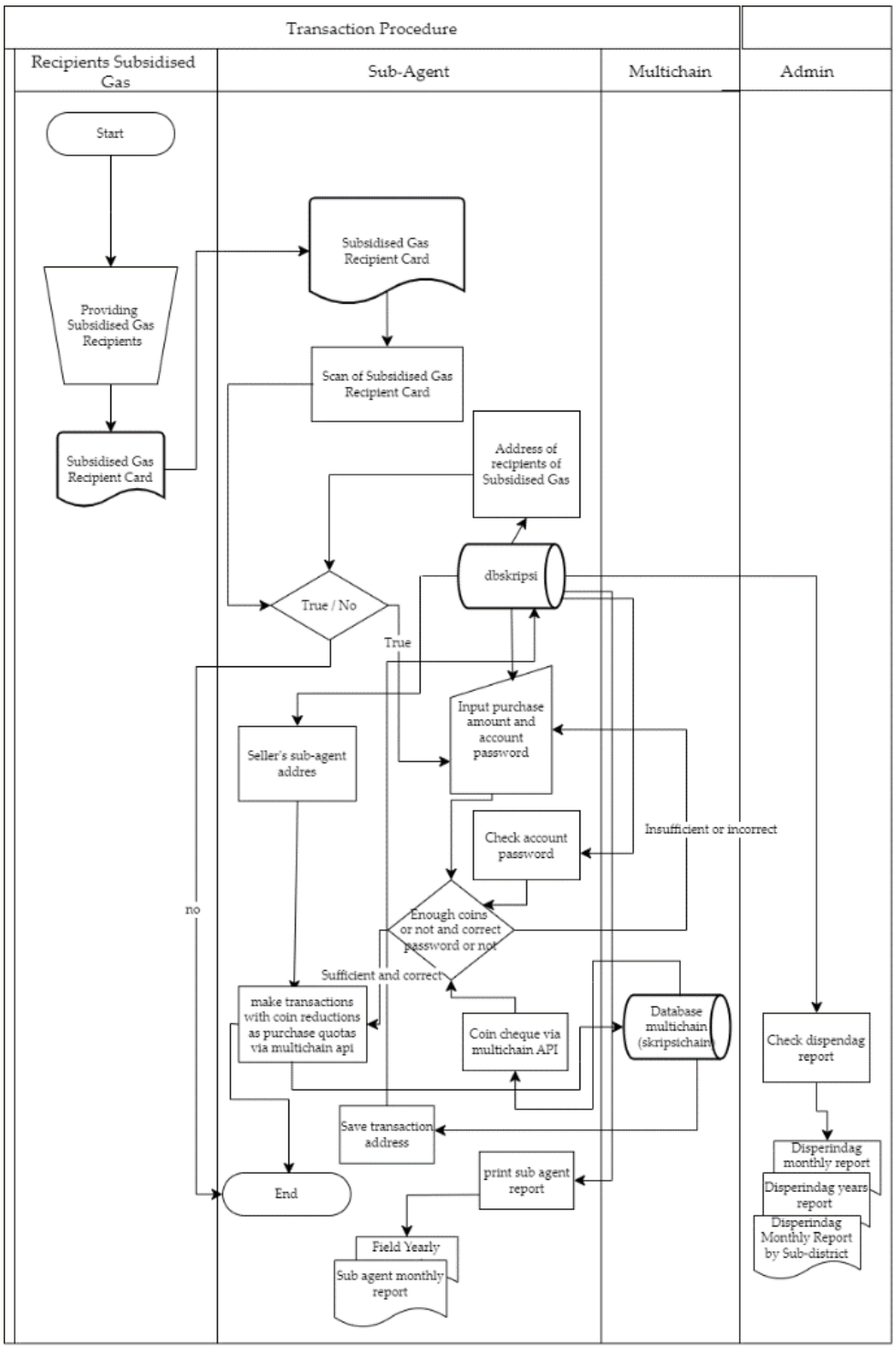

Figure 8. Flowchart Transaction

1) Context Diagram

The diagram illustrates the transactional procedure and data flow within a gas subsidy programme, which is administered by the Disperindag entity. The programme's core functionality is facilitated by a centralised Purchasing System, which serves as a repository for recipient data, transaction records, and subsidy allocations. The Sub-Agent, acting as an intermediary, utilises a Subsidised Gas Recipient Card to interface with the Purchasing System, thereby enabling the distribution of subsidies to eligible Gas Recipients. This interface enables the input of purchase amounts and account passwords, which are subsequently verified to ensure sufficient coins and correct password authentication. Upon successful authentication, the system processes transactions with coin reductions as purchase quotas via the multichain API, ultimately resulting in the provision of subsidised gas to recipients.

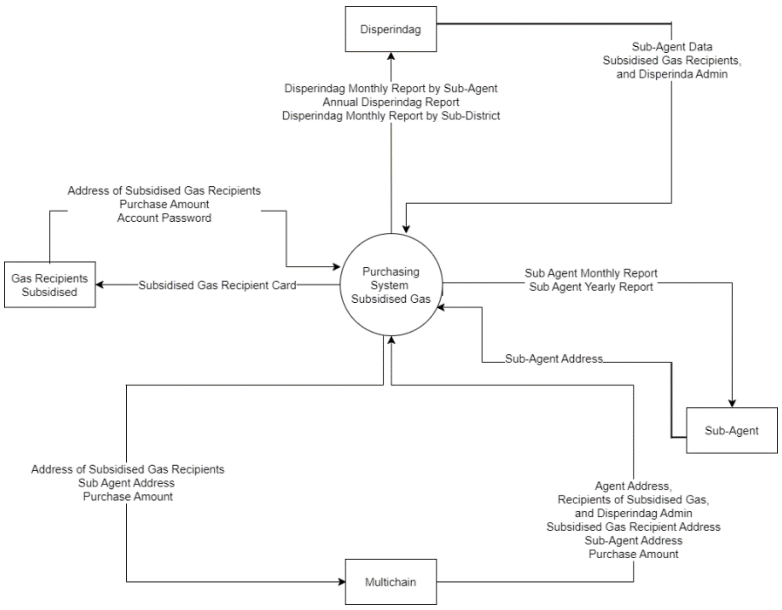

Figure 9. Context Diagram

2) Data Flow Diagram

1. DFD Level 1

The diagrammatic representation depicts the data flow within the gas distribution system. The system commences with the purchase of subsidised gas by recipients of the gas supply. The recipient of the gas provides the pertinent details (address, purchase amount, etc.) to the sub-agent. The sub-agent then stores this data and records the details of the transaction with the selling agent. The selling agents subsequently submit this data to Disperindag, along with their own data. This data is used to monitor subsidised gas transactions, thus ensuring fair and efficient distribution of this resource. The system facilitates the delivery of subsidised gas to those who need it, while providing a transparent and accountable framework for gas distribution management.

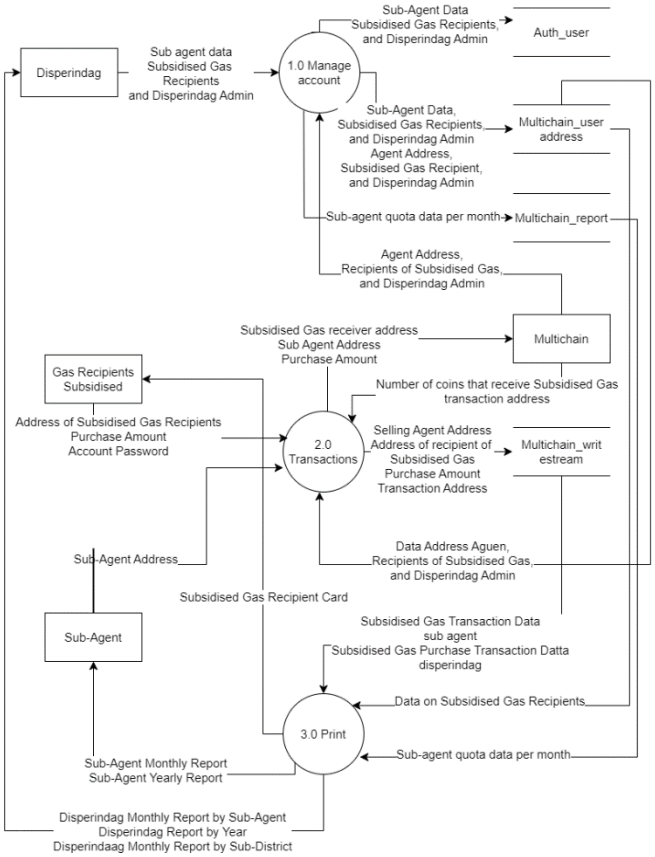

Figure 10. DFD Level 1

2. DFD Level 2 Account Processing

The image depicts a flowchart of a system for the administration of subsidised gas. The process commences with the establishment of a sub-agent account and the subsequent collection of sub-agent data. This is followed by the creation of a receiver account for subsidised gas, including the recipient's address. Finally, the system generates data on the recipients of subsidised gas and prints this information. The system also utilises a multichain network for the distribution of subsidised gas.

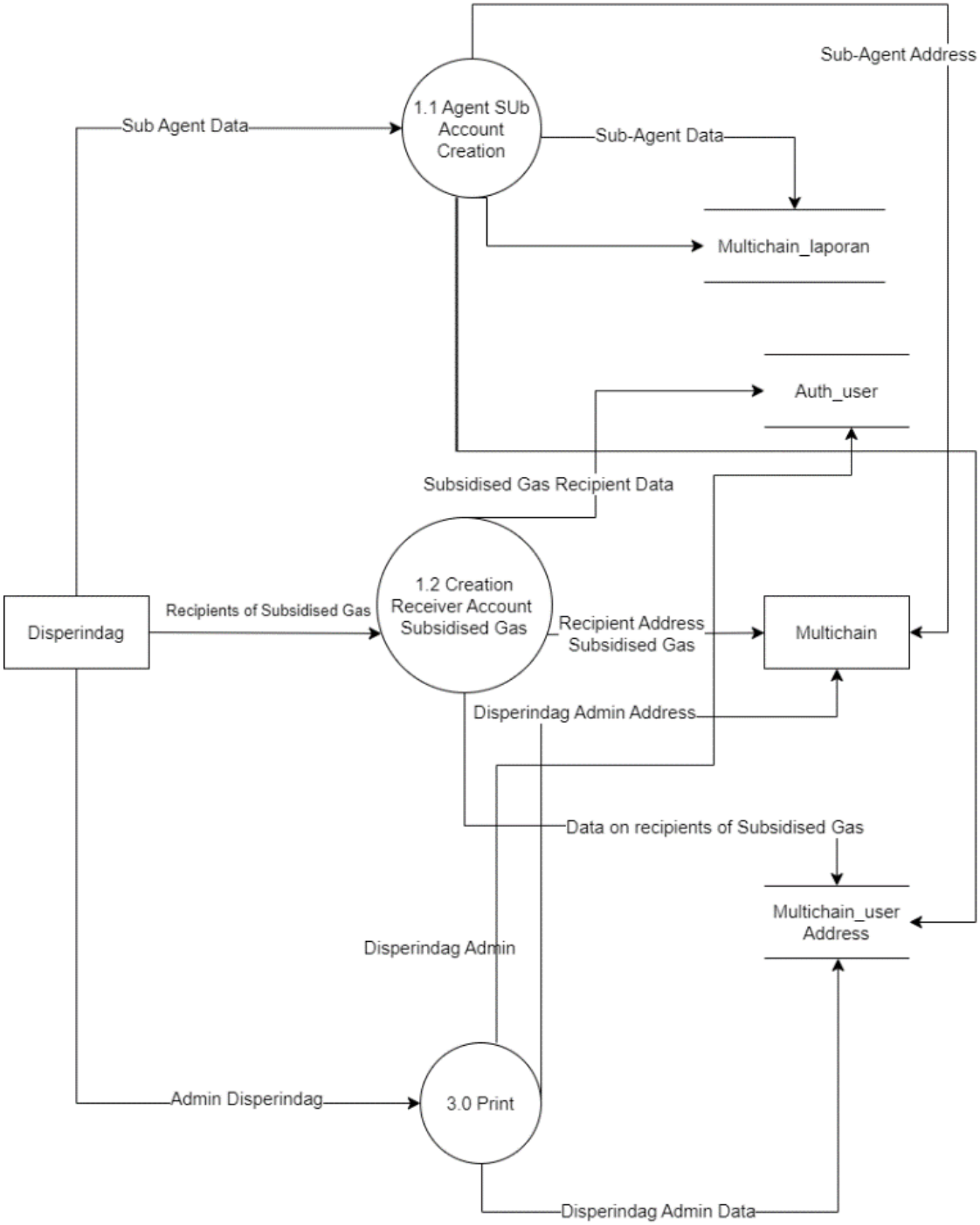

Figure 11. DFD Level 2

3. DFD Level 2 Print Process

The image depicts the data flow within a gas purchasing system. This system involves multiple parties, including a multi-chain platform, a sub-agent, a receiver account, and a disperindag. The process commences with a sub-agent receiving transaction data for subsidised gas purchases. This data is then transmitted to the receiver account, which is responsible for creating an account for the purchase. Additionally, the sub-agent is required to submit monthly and annual reports to the disperindag, which then generates its own monthly and yearly reports. Furthermore, the process is also regulated by quota data, which is used to track the amount of

gas purchased by each sub-agent. This data is used by the sub-agent to submit its monthly report to the disperindag. The image provides a visual representation of the data flow and the different parties involved in the process. Furthermore, the importance of reporting and data management in ensuring the efficient operation of the gas purchasing system is highlighted.

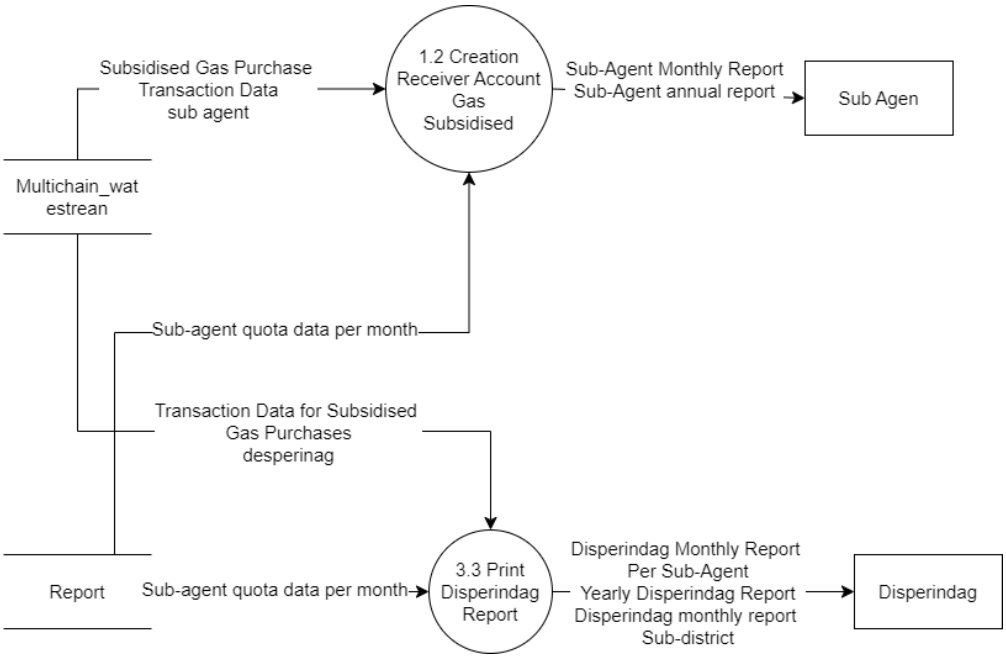

Figure 12. DFD Level 2 Print Process

4. Table Structure

Table 2. Auth_User

No	*Name of Field*	*Type*	*Long*	*Null*
1	Id	Int	11	No
2	*Password*	Varchar	128	No
3	*Last_Login*	Datetime	6	Yes
4	*Is_superuser*	Tinyint	1	No
5	*Username*	Varchar	150	No
6	*First_name*	Varchar	30	No
7	*Last_name*	Varchar	150	No
8	*Email*	Varchar	254	No
9	*Is_staff*	Tinyint	1	No
10	*Is_active*	Tinyint	1	No
11	*Data_joined*	Datetime	6	No

Tabel 3. Multichain_Useraddress

No	*Name of Field*	*Type*	*Long*	*Null*
1	Id	Int	11	No
2	*Address*	Varchar	100	No
3	*Name*	Varchar	100	No
4	*Nik*	Varchar	16	No
5	*No_Phone*	Longtext		No
6	*Qrcode*	Varchar	100	No
7	*Status*	Varchar	9	No
8	*User_Id*	Int	11	No
9	*Quota*	Int	11	Yes
10	*Tyoe*	Varchar	12	Yes
11	*Id*	Int	11	Yes
12	*Password*	Varchar	128	Yes
13	*Village*	Varchar	25	Yes
14	*Address*	Long_text		Yes
15	*RT*	Int	11	Yes
16	*RW*	Int	11	Yes
17	*Sub_agen*	Varchar	256	Yes

Table 4. Multichain_Writestream

No	*Name of Field*	*Type*	*Long*	*Null*
1	Id	Int	11	No
2	*User*	Varchar	100	No
3	*Buyer_Address*	Varchar	100	No
4	*Amount*	Int	10	No
5	*Created_At*	Date		No
6	*User_Id*	Int	11	No
7	*Address*	Varchar	100	Yes

Table 5. Multichain_Reports

No	*Name of Field*	*Type*	*Long*	*Null*
1	Id	Int	11	No
2	*Name_Sub_Agen*	Varchar	128	No
3	*Quota*	Int	100	No
4	*Month*	Int	10	No
5	*Years*	Int	11	No
6	*Quota_RT*	Int	11	No
7	*Quota_Industry*	Int	11	No
8	*Quota_Village*	Varchar	25	No

5. Program Structure

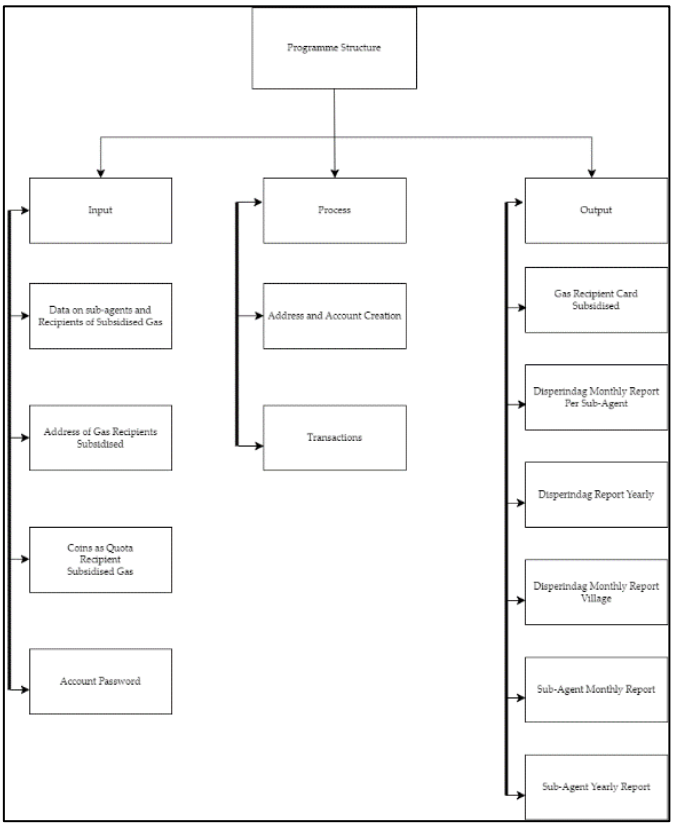

Figure 14. Program Structure

3.1 Trial System

3.1.1. Using Blackbox for Testing

Tabel 6. Black Box Testing

No	Description of Requirement	Testing Method	Expected Results	Description
1	Testing the login button on the user login page	Login on the user login web page	If the account is correct, enter the user page, otherwise, it will appear that the username or password is incorrect	√
2	Testing the login button of the Disperindag admin login page	login on the Disperindag admin login webpage	If the account is correct, log in to the Disperindag admin page, otherwise, it will appear that the username or password is incorrect.	√
3	Testing the login button of the sub agent login page	login on sub agent login web page	if the account is correct, enter the sub agent page, otherwise, it will appear that the username or password is incorrect	√
4	Testing the account creation button	Input all account creation forms on the admin page	All data successfully inputted	√
5	Testing the username data form on account creation	Input username on account creation and press the create me button input	If the username already exists, the username was successfully entered, if the username is available, a text will appear that the username has been used	√

6	Testing the email data form on account creation	Input email on account creation and press the account creation button input	If the email already exists, the email is successfully entered, if the email is available, it will appear that the email has been used	√
7	Testing the mobile phone number data form on account creation	Input mobile phone number on account creation and press the account creation button input	If the mobile phone number already exists, the mobile phone number is successfully entered, if the mobile phone number is available, a text will appear that the mobile phone number has been used.	√
8	Testing the password confirmation data form on account creation	Input password confirmation on account creation and press the account creation button input	If the confirmation password input is the same as the password, it will succeed, otherwise a message will appear that the password is not the same.	√
9	Testing the type data form on account creation	Input the type of account creation and press the account creation button input	If the status is customer, the type must be selected, if not selected, a text will come out that please fill in the type.	√
10	Testing the NIK data form on account creation	Input NIK on account creation and press the account creation button input	text that NIK does not contain 16 characters	√
11	Testing the sub agent data form on account creation	Input sub-agents on account creation and press the account input button	If the status is customer, sub agent must be selected, if not selected will exit please fill in sub agent	√
12	Testing the address, village, neighbourhood and neighbourhood data forms	Input address data for villages, neighbourhoods and hamlets	If the address data for urban village, neighbourhood and hamlet is empty, a form will appear.	√
13	Testing the search for transactions button on the Disperindag admin transaction search page	Enter the txid result and hash address that made the transaction or txid hash press search on the Disperindag admin transaction search page.	will display the searched transaction	√
14	Testing the search for transactions button on the search for sub-agent transactions page	Enter the txid result and hash address that made the transaction or txid hash press search on the sub agent transaction search page.	Will display the searched transaction	√
15	Testing the button to search for transactions that have been made on the transaction page that has been done by the user	Enter the transaction address and press the search button on the transaction page that has been done by the user	Will display the searched transaction	√
16	Testing the search button for transactions that have been made on the transaction page that has been done by the sub-agent	Enter the transaction address and press the search button on the transaction page that has been done by the sub-agent.	Will display the searched transaction	√

17	Testing the button to search for transactions that have been made on the transaction page that has been done by the Disperindag admin	Enter the transaction address and press the search button on the transaction page that has been done by the Disperindag admin.	Will display transactions that have been searched	√
18	Testing QR Code Scan	Scan QR Code and press the check address barcode button	QR Code scan results will appear and if the scan results are available will enter the transaction input page.	√
19	Testing the number of buyers data form in the transaction process	Buyer input	If the number of buyers does not match the available quota, an insufficient quota will appear, if available, it will be processed.	√
20	Testing the password confirmation data form on account creation in the transaction process	Input password.	If correct will be processed, if incorrect will remain on the page	√
21	Testing the monthly and annual report buttons on the sub-agent transaction list page	Enter the year in the annual report or enter the month and year in the monthly report, then press the print button.	Sub-agent's monthly report or annual report will be printed.	√
22	Test the monthly report by sub-agent, monthly report by neighbourhood and annual report by month buttons on the Disperindag overall transaction list page	Enter the month and year in the monthly report by sub-agent and monthly report by neighbourhood or enter the year in the annual report by month and press the print button.	Monthly report per sub-agent or monthly report per neighbourhood or annual report per month will be printed.	√

4. Conclusions

A private blockchain leveraging a multichain platform [15] with an advanced architecture can significantly enhance the efficiency and transparency of information systems used in the distribution of subsidised LPG gas, As in the background explanation above regarding the implementation that will be carried out in Medan City The implementation of a private blockchain platform with a sophisticated multichain architecture allows for the meticulous recording of the process of distributing subsidised LPG gas, thereby ensuring the accuracy and immutability of the data regarding the distribution. The system not only streamlines the logistics but also bolsters the integrity of the information by providing a secure, tamper-proof ledger.

Furthermore, in the transaction process for the purchase of subsidised LPG gas, the deployment of a private blockchain with a multichain architecture facilitates the identification of consumers eligible for the subsidy. This mechanism facilitates the verification of recipient identity data by sub-agents with greater ease and accuracy, thereby reducing the risk of fraud and ensuring that benefits are distributed to the intended recipients. This approach exemplifies how cutting-edge blockchain technology can be harnessed to address and overcome challenges in public welfare distribution systems.

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