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The preliminary study of carbon x-change rakyat using blockchain application

Wahyu Sasongko Putro[1], Nitia Rahmi[1], Raditya Yoga Asditama[1], Nur Arifin Akbar[2]
[1]Digital Banking Development Division, Blockchain Centre of Excellent, Bank Rakyat Indonesia, Jakarta, Indonesia
[2]Dipartimento Matematica e Informatica, Universitá degli Studi di Palermo, Palermo, Italy

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ABSTRACT

Today's air pollution is detrimental to the environment, particularly in Indonesia. Carbon dioxide (CO_2) and nitrogen oxide (NO_x) are present in the atmosphere due to air pollution. Many individuals employ reforestation to lessen the influence of CO_2 and NO_x gases on the atmosphere. However, in the digitalized era, lowering carbon emissions may also be accomplished through a carbon credit exchange. Thus, in this study we investigate the performance of the carbon x-change rakyat (CXR) based on blockchain platform utilizing the stress test approach. We provided four scenarios with 10,000 to 100,000 transactions evaluated on the CXR blockchain system i.e., transfer, insert, remove, and update. The outcome demonstrates CXR's effectiveness with 100% success and 0% failure rate based on testing and statistical computations calculation. The mean absolute error (MAE), variance accounted for (VAF), and percent error (PE) are obtained with values ranging from 0.38% to 4.67%. In this study, the transaction per-second (TPS) is used to calculate include error request (IER) and exclude error request (EER) values around 312 to 746 milliseconds (ms). In addition, the TPS of CXR based on blockchain platform is a capability to create and trace database carbon certificate ownership (nonfinancial activity). It means CXR based on the blockchain platform has a fast response to process carbon certificate ownership for transactions across local and international countries in the world.

Corresponding Author:

Raditya Yoga Asditama
Digital Banking Development Division, Blockchain Centre of Excellent, Bank Rakyat Indonesia
Jakarta 10210, Indonesia
Email: raditya.yoga@work.bri.co.id

1. INTRODUCTION

The earth's ecosystem has decreased due to greenhouse gases from human activity. This activity harms the earth's ecosystem, such as rising sea levels, acidic oceans, and extreme weather [1]. During extreme weather, the temperature was increased due to carbon emissions, especially in the equatorial region [2]. Regarding on 2015 Paris Agreement, the temperature ambient in the equatorial country increased from 1.5 °C to 2.0 °C due to carbon emission [3]. Thus, many researchers were studied to monitor high temperatures using mesoscale convective systems (MCS) model [4]. Here, the MCS model was proposed to study characteristics of meteorological parameters, including high temperature. In this study, the high temperature was increased in the equatorial country, especially in Tawau, Malaysia.

Here, the MCS model (surface temperature model) was compared for three years observation using global positioning system (GPS) and surface meteorological data. The comparison result shows surface temperature increased 0.8 °C to 1.7 °C based on the MCS model and three years of observation data using

GPS and meteorological data. Furthermore, in the wet season the surface temperature was increased 0.1 °C and thunderstorm events are obtained over the observed area. Thus, the multiple linear regression, Dvorak, and adaptive neuro fuzzy inference system (ANFIS) was proposed to see thunderstorm activity and surface temperature during the wet season [5]. Here, the thunderstorm activity increased over inter monsoon season with a significant surface temperature increase +0.3 degree Celsius over the observed area. The result shows the frequency of thunderstorm activity and surface temperature are increased due to climate change captured in this area. This phenomenon is caused by industrial activity and mining exploration. Thus, the air pollution from each industry contributed to the increasing carbon capture index due to climate change.

Furthermore, in Indonesia the carbon capture index from industrial activity and mining exploration increased per-years [6]. The reforestation activity to reduce the carbon footprint index was conducted by the Indonesian government and the green industry. However, during the digitalized era, reforestation activity was changed based on carbon exchange. Thus, this study aimed to study digital reforestation using blockchain over carbon x-change rakyat (CXR) platform using a stress test method. Here, the reforestation digital platform using blockchain carbon exchange is recommended solution to reduce the carbon emission index [7]. In addition, blockchain technology can improve accountability, transparency, and efficiency of digital reforestation from the carbon emission index [8]. Here, the blockchain application was composed of two processes such as mining and validation [9]. Here, mining is adding a new transaction block to the global public ledger from the previous block (more than one block) process, while validation is a process of validating the new block added. However, in this study, the consortium blockchain was used during validation of the new block (private blockchain with permitted Team members). Here, the CXR blockchain system is used practical byzantine fault tolerance (PBFT) method to validate database of carbon certificate ownership from consortium blockchain. It means CXR based on the blockchain platform has a fast response to process carbon certificate ownership for transactions across local and international countries in the near future.

2. METHOD

2.1. Blockchain carbon capture application

Blockchain is sustainable technology to offer of high-security level. Here, the blockchain is in various distributed system contexts, including content distribution networks [10], e-Healthcare [11], smart industries [12], and carbon capture applications [13]. In addition, the blockchain for green technology can be designed as a blockchain carbon exchange application. Figure 1 shows flowchart blockchain architecture for carbon exchange application [14].

As shown in Figure 1 the two systems (inside blockchain carbon exchange application), node application (CLI) and web application, have been created to obtain regulator, report, and market validation. Here, the two applications were addressed at a replicated web server, especially for application programming interface (API) for identity management and wallet. Furthermore, the blockchain API is used as a permission tool for carbon exchange blockchain over system applications. Thus, the blockchain API is a primary tool to control carbon exchange blockchain from start to end of a transaction. Here, several consensus protocols over API blockchain have applied to validate data transactions. During the validation process, the practical byzantine fault tolerance (PBFT) was contributed to compare data transactions per node under the registered API blockchain. Figure 2 shows the mechanism PBFT per node over blockchain configuration [15].

As shown in Figure 2, the algorithm PBFT over carbon exchange is located at the node blockchain to validate all transactions. Here, the client (user or buyer carbon exchanger) sent the request to zero nodes and separated it into first to third nodes. Moreover, in the first and second nodes, the request was distributed in the pre-prepare step with scattered into six lines inside prepare step. Furthermore, the six lines over the prepared step will be scattered into nine lines at the commit step. To make the final decision from the commit step, the blockchain system will use three lines of data reference to validate client transaction requests.

2.2. Stress test method

In this study, the stress test method was proposed to obtain system performance results during the total number of transaction carbon exchanges. In addition, the adjustment parameter must be prepared before the stress test method is applied to CXR blockchain system. Table 1 shows the prepared parameter during the stress test method over the CXR blockchain system.

As can be seen in Table 1, the six object parameters are proposed to make sure the system is in good condition while compiling the transaction. Here, the six-object parameter will be applied to four scenes such as transfer, insert, remove, and update. In this study, we define the two objects of work, including four scenarios to obtain a good blockchain performance. Figure 3 shows the two objects of work, such as the stress test mechanism (SDK) and configuration nodes (CXR platform blockchain) was performed to obtain the total number of transactions per second (TPS) in four scenarios.

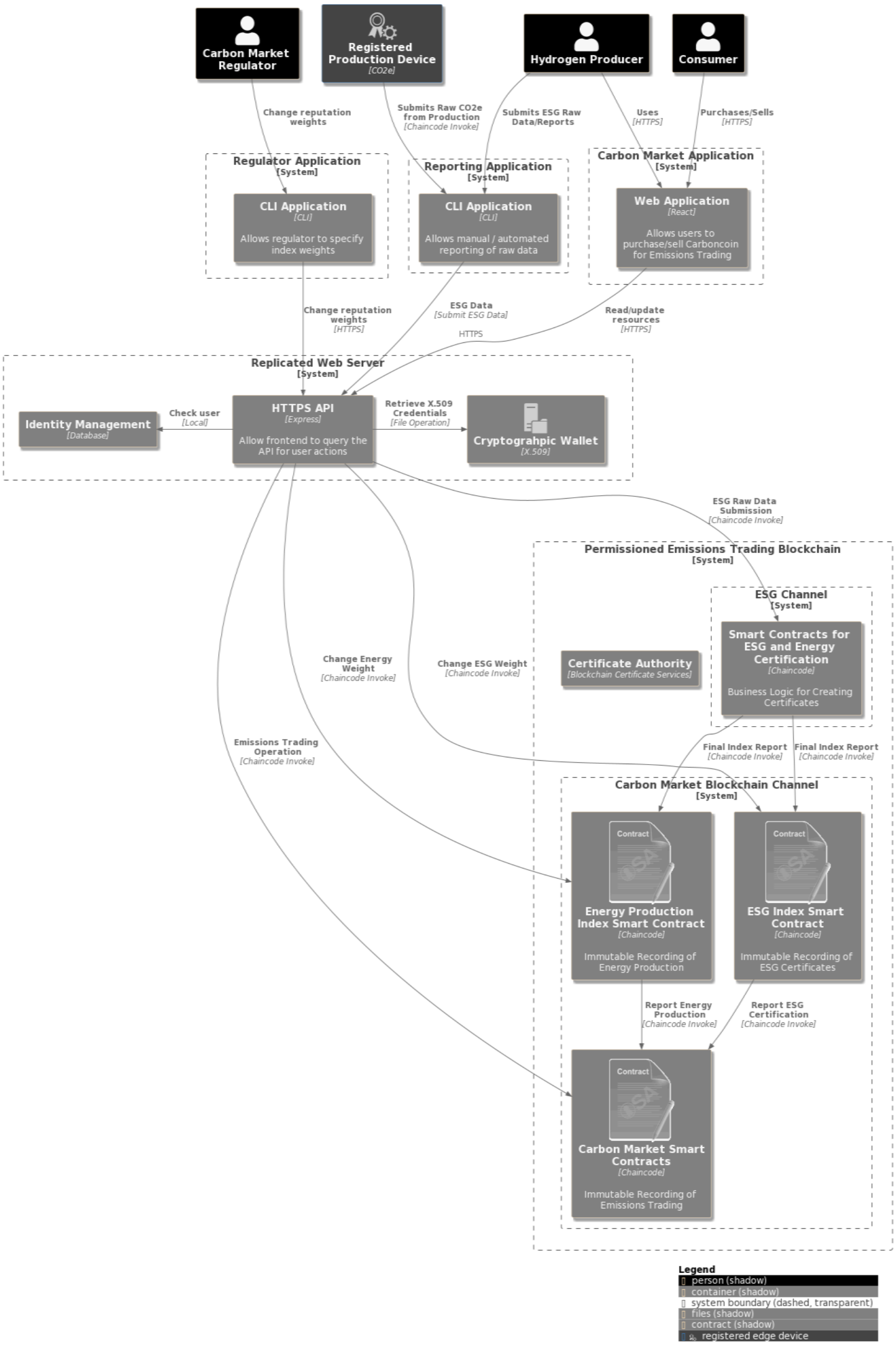

Figure 1. Flowchart blockchain architecture on carbon exchange (general application)

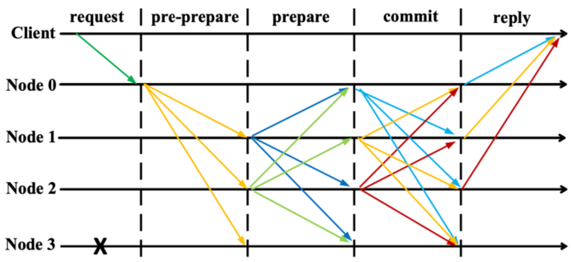

Figure 2. Mechanism PBFT over blockchain on carbon exchange application

Table 1. Prepared parameter object during stress test method over CXR blockchain platform

No.	Prepared parameters object	
	List object	Term and condition (TOR)
1.	Total number of transactions (TPS)	TPS must be reached 5,000 transaction per minute
2.	Queries per second (QPS)	Sending capacity of TPS performance not reached 10,000 levels.
3.	Contract complexity	Must be have amount of code, support parallel transaction logic, and the amount of data.
4.	Chain parameter configuration	Transaction pool at 500 milliseconds (minimum)
5.	Hardware configuration	Must use high-speed mechanical hard disks or SSD hard disks, and relatively low-speed network storage devices with caution.
6.	Other	Must be set the stress test log level of client and chain to the minimum error over blockchain system.

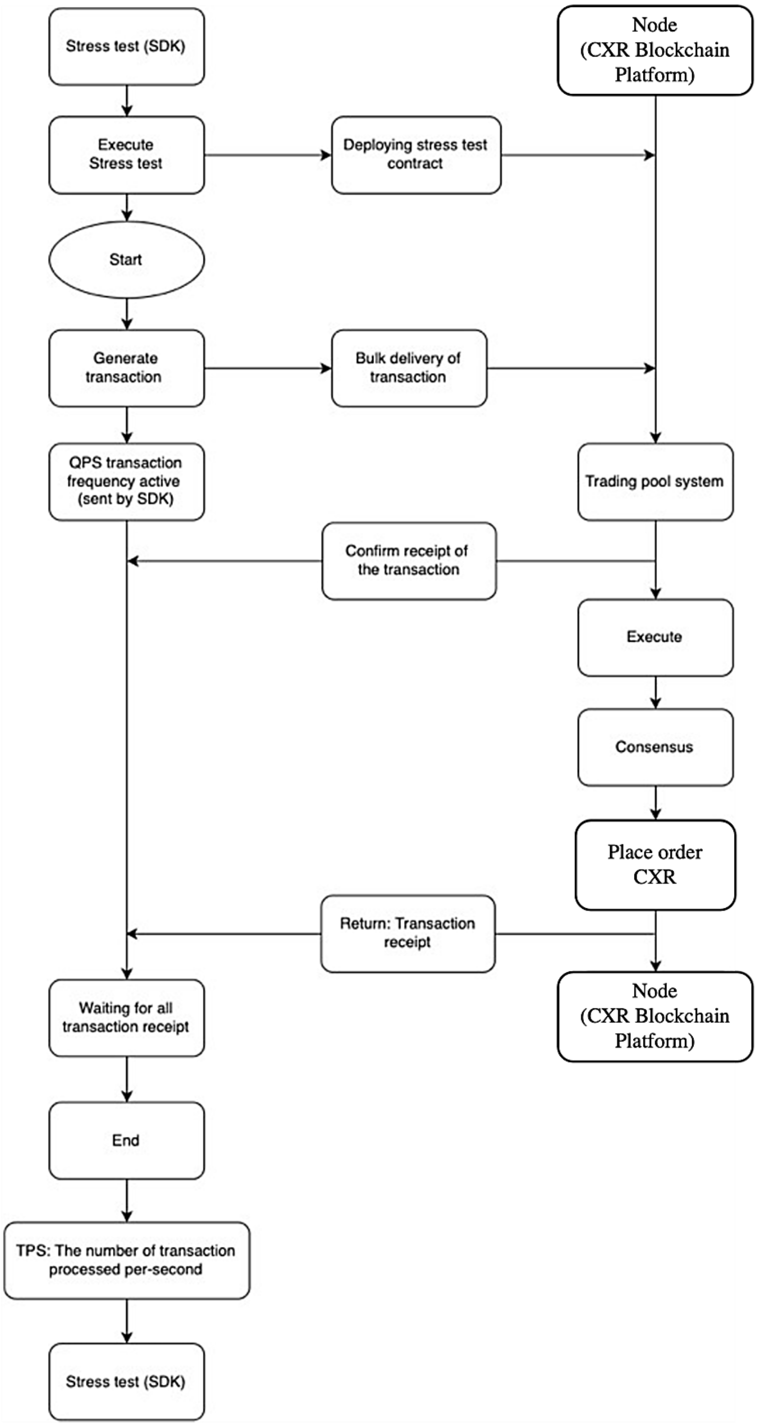

Figure 3. Flowchart mechanism between the stress test method and CXR node blockchain platform

Figure 3 shows the execution process started from deploying a stress test contract and delivering the bulk of transactions over nodes CXR blockchain platform to generate a trading pool system. In addition, the generating trading pool system was confirmed to provide queries of query per second (QPS) transaction frequency from SDK. During the compiler process, the trading pool system created a consensus to place order CXR and generate transaction receipt from QPS transaction frequency active. Furthermore, the transaction receipt will be published after validation of the requested amount of TPS.

2.3. Data and location

The data observation was created by a blockchain developer (per scene) in this study. Here, all the component data observation was tested and filtered using the stress test method to obtain the best blockchain performance. Table 2 shows the component parameter of data observation on CXR blockchain over the cloud computational process. Here, the component data observation based on user amount at pulling data was tested using the stress test method over different scenarios to obtain transaction per-second (TPS). This test is located at the cloud and local server BRI office in Jakarta, Indonesia.

2.4. Statistical analysis

To analyze the total time (TT) and average time cost (ATC) during stress test over CXR blockchain platform, we proposed statistical analysis such as mean absolute error (MAE), variance accounted for (VAF), and percent error (PE). In this study, the three statistical analyses are provided to calculate accuracy from stress test method over four scenarios such as transfer, insert, remove, and update by (1) [16], [17].

$$MAE = \frac{\sum_{i=1}^{n}|y_i - x_i|}{n} \tag{1}$$

where, the parameter y_i, x_i, n stand for estimation result, true value, and total number of data, respectively. In another study, MAE is used to calculate absolute error from carbon capture model [18] and thunderstorm activity [19] between estimation true value and estimation result. Furthermore, we also calculate the percentage between real output and estimation result, we use VAF by (2) [20], [21].

$$VAF = \left(1 - \frac{var(y_i - y_i')}{var(y_i)}\right) \times 100\% \tag{2}$$

where, y_i is a real output while y_i' estimated output. Here, VAF was used to make sure the calculation TT and ATC from MAE is good. Here, the VAF formula was used to obtain percentage from estimation carbon footprint model [22] and cosmic ray model during increasing pollutant over equatorial area. Here, we also use PE (δ) to obtain percentage from actual value and expected value during stress test over CXR blockchain platform over equatorial area by (3) [23]–[25].

$$PE\ (\delta) = \left(\frac{v_a - v_b}{v_b}\right) \times 100\% \tag{3}$$

where, v_a and v_b stand for actual value observed and expected value, respectively. During stress test over CXR blockchain platform, PE was used to validate VAF from expected value (estimation output). In this study, the statistical method was used to validate TT and ATC over four scenarios during stress test over CXR blockchain platform.

Table 2. Component data observation data during stress test over CXR blockchain

No.	Component parameters of data	
	Data type	Amount of data
1.	Variation of total transactions	10,000 to 100,000 transactions
2.	Time limit	2,000 milliseconds
3.	Transaction error request	< 400.00 transaction
4.	Queries per-second (QPS)	2,000 to 4,000 milliseconds

3. RESULTS AND DISCUSSION

To achieve the result, we proposed several steps and stress methods to analyze the transaction CXR blockchain platform. In this study, we design a node CXR blockchain with several databases to process a transaction as shown in Figure 4. Figure 4 shows several steps, such as set-up the cloud and local server CXR with queries database designed for a fundamental blockchain system. Before beginning the installation, we use google cloud platform (GCP) to deploy blockchain system with several setting (hard-disk space and RAM memory). The resource of blockchain is fully open source (downloaded from GitHub). Afterward, the node and smart contract blockchain was enhanced to obtain the good result based on use case. In this study, we choose the blockchain carbon exchange use case to obtain transaction per second (TPS). In addition, the TPS feature will be used for transactions between seller or buyer carbon exchange at front-end web base and connected with API also bridging with Java middleware. Hence, the stress test method was proposed to validate the transaction process over Java middleware (bridging transaction process and blockchain platform). We created four scenarios table test such as transfer, insert, remove, and update with a variation of total transaction buyer and seller 10,000 to 100,000 transaction.

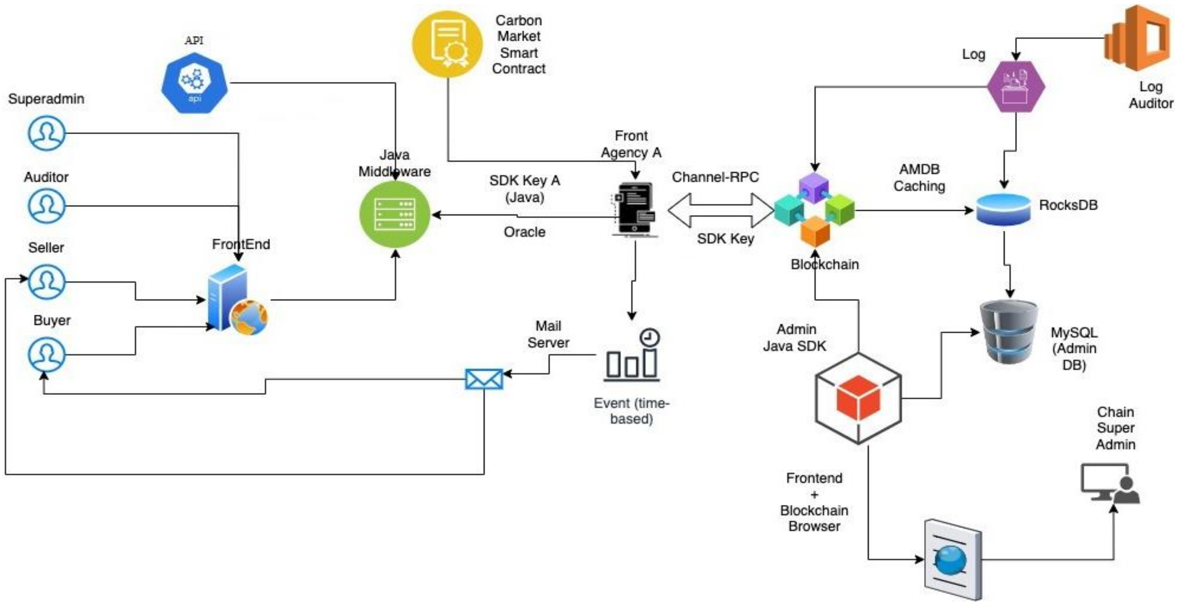

Figure 4. Configuration CXR blockchain system

Here, we calculate total time and average time cost for comparison purposes over four scenarios table over test 10,000 to 100,000 transactions using stress test method as shown in Table 3. Table 3 shows that the four scenarios (inside table test), such as transfer, insert, remove, and update, were successfully calculated while the compiling transactions per second (TPS) reached 10,000 to 100,000 transactions using the stress test method. Here, we obtain 100% success and 0% failure rates from the testing result, respectively. In addition, all the testing results showed different calculation times such as total time (TT) and average time cost (ATC). The differences between the two types of time are located in processing the queries of transactions per second (QPS) over four scenarios (inside table test). To obtain the time gap between TT and ATC, we analyzed based on statistical calculations such as mean absolute error (MAE), variance accounted for (VAF), and percent error (PE) as shown in Table 4.

As can be seen in Table 4, the gap time minimum between four scenarios is shown over the transfer and remove scenarios while the gap time maximum is update and insert scene, respectively. Here, the two scenes such as update, and insert has taken time to execute into query on CXR blockchain data base transaction while the transfer and remove scene not too much taken time. The taken time to execute a database query depends on the server location (local and cloud server). Thus, the update and insert scene was executed on a cloud server while transfer and remove scene were over a local server, respectively. To obtain good performance on CXR Blockchain transactions, we calculate TPS including and excluding error requests as shown in Table 5.

Table 5 shows that the error rate from CXR Blockchain transaction over four scenarios are zero percent with a tolerance measurement of five percent (maximum). To see the error rate TPS, we compared IER and EER over four scenarios. Here, the same value is shown over TPS columns IER and EER. Based on the calculation result, we obtain the good performance of CXR blockchain TPS using a combined server (cloud and local) with stress method assessment over the equatorial country in the near future.

Table 3. Comparison of transaction during stress test over CXR blockchain

Name		Success (%)	Failure (%)	Total time (TT)	Avg. time cost (ATC)
Table Test Scene	Transfer	100	0	133.950 ms	71.646 ms
	Insert			266.786 ms	110.269 ms
	Remove			270.589 ms	153.417 ms
	Update			320.388 ms	165.395 ms

Table 4. Time gap calculation based on statistical analysis between TT and ATC during stress test over CXR blockchain

Name		Gap TT and ATC (ms)	Statistical analysis		
Table Test Scene	Transfer	62.304	0.639	0.389	2.682
	Insert	156.517	1.577	0.796	4.674
	Remove	117.172	1.187	0.702	4.216
	Update	154.993	1.554	0.741	4.638
	Transfer	62.304	0.639	0.389	2.682

Table 5. Transaction per second (TPS) during stress test over CXR blockchain

Name		Error rate (%)	Transfer per-second (TPS)	
			Include error request (IER)	Exclude error request (EER)
Table Test Scene	Transfer	0	746.550 ms	746.550 ms
	Insert		374.860 ms	374.860 ms
	Remove		369.550 ms	369.550 ms
	Update		312.120 ms	312.120 ms

4. CONCLUSION

The preliminary study of CXR was successfully studied. Here, the blockchain system with selected virtual machine and node configuration over CXR is provided to obtain a good TPS performance. In this study, the stress test method is proposed to obtain a good TPS over CXR performance. The four scenes such as transfer, insert, remove, and update with 10,000 to 100,000 transactions were tested over CXR blockchain system using the stress test method. During the testing process, we obtained 100% success and 0% failure rates in CXR blockchain system, respectively. Here, TT and ATC are the difference (per scene) due to database location processing (cloud and local) over queries of transaction per second (QPS) inside of CXR blockchain system. To see the differences (gap) between TT and ATC, we analyze using statistical calculation over CXR blockchain system. In addition, the TPS was also performed to obtain a good result from CXR blockchain system. To see the performance, we compare the error rate of TPS from IER and EER over four scenarios over CXR blockchain system. Based on the calculation result, the combined server (cloud and local) with four scenes using the stress test method have a good result. Here, we proposed CXR blockchain system as a marketplace tool with stable transactions in the near future.

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BIOGRAPHIES OF AUTHORS

Wahyu Sasongko Putro received a B.Eng. degree in engineering of physics from Institut Teknologi Sepuluh Nopember (ITS), Indonesia and M.Sc. degrees at Institute of Climate Changes from Universiti Kebangsaan Malaysia (UKM), Malaysia. Currently, he is an IT Officer at the blockchain center of excellence, Digital Banking and Operation Division PT. Bank Rakyat Indonesia, Tbk. He has authored ISI, Scopus index journals, conferences, and also books chapters in the research area. His research area includes climate changes in extreme weather, carbon emission, blockchain applications, and artificial intelligence for atmospheric disaster. He can be contacted at email: wahyu.sasongko@work.bri.co.id.

Nitia Rahmi received the B.Sc. degree in informatics engineering, Bandung Institute of Technology, Indonesia and M.Sc. with Distinction at University of Leicester, United Kingdom. Currently, she is team lead blockchain center of Excellence Digital Banking and Operation Division PT. Bank Rakyat Indonesia, Tbk. She has versatile experience working in diverse banking and financial service application development for 12 years. She is interested in any kind of software model development and blockchain system. She can be contacted at email: nitia.rahmi@work.bri.co.id.

Raditya Yoga Asditama received the B.Eng. degree in telecommunication engineering from Telkom University, Indonesia, in 2021. Currently serves as IT Officer at Blockchain Center of Excellence Bank Rakyat Indonesia. His research interests include artificial intelligence, blockchain, energy, machine learning, and the internet of things. He can be contacted via email: raditya.yoga@work.bri.co.id.

Nur Arifin Akbar is a Ph.D. candidate under the Marie Curie Doctoral Network. He holds B.Sc. degrees in electrical engineering from Diponegoro University, and M.S Degrees from Universitas Amikom Yogyakarta and Universidad De Murcia, Spain. His research interests include artificial intelligence, distributed applications, energy, machine learning, and blockchain. He has authored and reviewed several ISI and Scopus journal and conference papers. He can be contacted at email: nur.arifin.akbar@gmail.com.