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A Fintech Platform Using Blockchain Smart Contract

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Abstract— **Though few blockchain-based payment services are currently available, this is expected to change in 2018, as investment has poured in from banks to explore blockchain's potential. This creates the potential for developing live blockchain payment processing solutions and trade finance deployments. However, current blockchain technology is unsuitable for real-world applications owing to various limitations. Bitcoin is simply a "virtual" currency or "cyber" money because blockchain does not support owner identification. This study combines credit card payments and a blockchain network to overcome this limitation. If there is no connection between the credit card payment system and the blockchain network, blockchain ciphers like Bitcoin will remain a "virtual" currency or "cyber" money forever. This paper presents a challenging study involving blockchain and financial technology (fintech). Furthermore, we must consider the integration approach in terms of performance. Even the performance of state-of-the-art blockchain platforms cannot meet fintech application standards in the real world. In order to resolve performance issues related to a blockchain network while processing credit card transactions, we exploit the overlay network concept to separate the credit card network from the relatively slow blockchain peer-to-peer (P2P) network. In this paper, we presented the details of the data preparation, assessment metrics, and evaluation of our method. We also described the experimental results for the fintech platform using blockchain smart contracts.**

Keywords— **Fintech; blockchain; credit card payment platform; overlay network.**

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I. INTRODUCTION

Fintech is a converged term of financial and technology, with traditional financial methods in delivering financial and technology services [1]. Recently, the world's leading global companies have been actively conducting R&D on smart contracts and e-commerce technologies using blockchain platforms. The use of blockchain technology and e-commerce convergence is increasing worldwide. This study reviewed the trends in R&D in related fields and examined the possibility of applying blockchain smart contract technology to the FinTech platform. The world's leading global companies are developing the following technologies in this regard. Microsoft has released a preview version of ION (Identity Overlay Network), a decentralized identification project based on the Bitcoin blockchain, as an open source. In the Libra white paper, Facebook argued that it would innovate digital identity in a decentralized direction. IBM has already started developing DID services by joining Yellow Pages, a decentralized network for blockchain projects [2].

In a blockchain-based decentralized operating environment, raw data about the e-commerce transaction is stored in an off-chained operating environment such as the Sidetree protocol [3]. This includes data related to credentials and other information necessary to prove transaction facts. In the blockchain fintech platform, various information data is stored in a decentralized Identity Hub, etc., and personal information data can be provided when a company or other person requests it only as much as the permitted portion of the individual who is the data subject. Therefore, it is possible to reduce the abuse of personal information, and even if the personal information is leaked, there is an advantage of reducing the risk because it is only a part [4], [5]. Figure 1 shows the classification of organizations in which computers are connected.

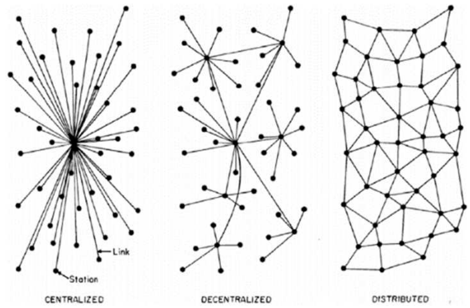

Fig. 1 Network organization classification

Computing architecture is classified into centralized, decentralized, and distributed [6]. One or more terminals are connected to a single processor in centralized processing. On the other hand, blockchain technology is a technology that has the following features [7]–[9]. For example, decentralized/distributed system architecture, good scalability, a transparent and immutable/irreversible shared database, and smart contracts for multi-party interaction with no intermediary.

The fintech blockchain network covered in this study is a fusion of decentralized and distributed architecture. We are choosing a converged approach between distributed and decentralized because the communication overhead in totally distributed computing environments is very high. Performance improvement of the blockchain platform alone cannot meet the current global blockchain R&D trend or direction [10], [11].

Fig. 2 Variety of Fintech technologies on applications

Meanwhile, we do not fully depend on the decentralized architecture because it is difficult to realize the decentralized control architecture that is inherently targeted in blockchain. [12] states that blockchain and tokenization are especially important disruptive trends in the payments sector of the fintech industry. [13] explains that many blockchain and fintech-based mobile banking startups are opening in Silicon Valley. From these trends in fintech, we need to design a flexible computing platform rather than a distributed or decentralized architecture [14], [15].

Blockchain is effective in preventing forgery and hacking via data manipulation. However, since blockchain does not have a personal identification and authentication technique, it is impossible to replace the public certificate[16]–[19]. For example, Bitcoin is identifiable up to the Bitcoin wallet, but it does not identify the owner of the wallet. Hence, a wallet is irretrievable if a user loses a password when using Bitcoin. However, if a user cannot identify the owner of the Bitcoin in the blockchain, it is equivalent to “cyber” money or “virtual” money. Therefore, this study evaluates an important/necessary biometric technique for identifying the owner of virtual currency or cryptographic money. In addition, we discuss an article that considers the need for blockchain to be combined with public key infrastructure (PKI), biometric authentication, and other means of identity verification.

The current blockchain technology is insufficient to replace the current PKI certificate. Bitcoin is just a “virtual” currency or “cyber” money if blockchain does not support owner identification by a method such as PKI certification [20]. For example, as shown in Figure 3, virtual or cryptocurrencies can identify the owner machine but cannot identify the machine's specific owner (person) using blockchain architecture. This is an incredibly significant drawback of blockchain systems for fintech. Our research focuses on a very creative and challenging field of study involving blockchain and fintech. We will attempt to integrate the two fields to achieve the research objective. Because blockchain does not support owner identification, Bitcoin is simply a “virtual” currency or “cyber” money.

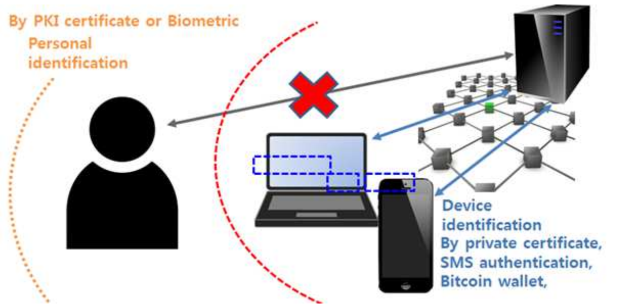

Fig. 3 Current blockchain limitations due to the identification problem

In order to resolve such a limitation, we combined credit card payments with a blockchain network. If there is no connection between the credit card payment system and the blockchain network, blockchain cipher such as Bitcoin is forever a “virtual” currency or “cyber” money. Our research is a challenging study involving blockchain and fintech. We must also consider the integration approach in terms of performance. Even the performance of state-of-the-art blockchain platforms cannot meet the performance of fintech applications in the real world. In order to resolve the performance issues of blockchain networks in processing credit card transactions, we exploit the overlay network concept to separate the credit card network from the relatively slow blockchain P2P network.

Various projects are carried out in overseas markets, mainly in the US, Europe, and Asia [21]–[23]. Most businesses collaborate with finance and pinch companies related to blockchains to provide a new financial business model [24]. Most of them do not go through exchanges, but users can conveniently use financial services such as remittance and securities.

R3 CEV: R3 CEV is a consortium established for research and development to utilize blockchains and dispersal ledgers in financial transactions, including 40 banks, including Goldman Sachs, Barclays, and JP Morgan. Since then, financial companies have been expanding with additional subscriptions. Shinhan Bank joined the consortium for the second time in Korea, followed by Microsoft, Itau Unibanco in Brazil, Ping An in China, and AIA in Hong Kong. Currently, the consortium joins the R3 consortium [25].

R3 CEV and the world's leading banks and financial institutions recently announced the recruitment of new talent, including James Carlyle, a former senior technician at Barclays, and Mike Hearn, a Bitcoin Core developer. We are studying blockchains at various angles to determine the optimal application method. R3 CEV has already conducted two online distributed book system tests recently.

Blockchain [19] CG is a community established within the World Wide Web Consortium (W3C), an international organization that develops and promotes standards for the World Wide Web (WWW) and is the world's first standardized open-chain block standardization group. We are studying the standardization of blockchains through collaboration with domestic companies, schools, and research institutes in over 12 countries, including the USA and UK. We are examining compatibility with ISO20022 and aiming to make an open API standardization white paper based on blockchain in the future. In contrast to the R3 CEV, a blockchain CG and a representative blockchain consortium, it is not only financial but also all IoT, e-government, and telemedicine. It is to perform and standardize the requirements of the potential industry. Also, it aims to derive standards and technology for public networks instead of developing standards for private networks like R3 and disclose all technology and documents free of charge to reduce network maintenance costs of public institutions and companies [26]–[30].

The multi-parties for Hyperledger projects are involved in this project, which covers a wide range of open-source software so that all transaction history is protected by encryption and disclosed to all participants in the network. They developed an optimized blockchain technology for the enterprise (other IT companies such as Intel and Cisco also participated). The rest of the paper is structured as follows: Section 2 discusses related work in this field. In Section 3, we present our proposed methodology. In Section 4, we evaluate the performance of our implemented system. Finally, we present the conclusions of our research in Section 5.

II. MATERIALS AND METHOD

Assume we are not required to sign a PKI certificate when making a credit card purchase; if biometric technology is not achievable for large payments by credit card (fintech), then nobody will pay the with credit card usage fee. If purchasing a large amount of merchandise with a credit card and not signing an official certificate, the credit card payment may be denied, and as a result, the payment is not sent; this is a problem with the fintech system itself. In the case of a dispute between the card user and a seller or the card company itself, and Visa/Mastercard does not require the user to sign a certificate, it will intervene according to the dispute settlement procedure. In addition, introducing a fraud detection system (FDS) detects and prevents fraud in real-time.

Since 2015, Korea has relaxed the requirements for the use of public certificates. As a result, credit card companies must autonomously strengthen security through FDS or biometric verification. FDS and biometrics are increasingly being introduced. For example, in the field of global fintech business, Visa/Mastercard companies do not require signing a PKI certificate at the time of payment. However, they provide arbitration via a dispute resolution center. Moreover, they make use of the FDS for every credit card transaction. The incremental growth of computer technology use and companies' continued growth have enabled most financial transactions to be performed through electronic commerce systems. Specifically, an autonomously strengthened security policy currently popular is as follows: If someone purchases exceeding 300,000 KRW, credit card companies require them to sign a PKI certificate or verify themselves through SMS authentication. There is an additional option for payment verification in biometric authentication using smartphone biosensors.

A. Overall Architecture

Currently, credit card companies autonomously attempt to strengthen their security level. Most recently, the popular approach in Korea is as follows: If a purchase amount exceeds 300,000 KRW, the card owner must confirm their identity via PKI certificate or SMS authentication.

Figure 4 shows that this architecture is based on cloud computing infrastructure; we use the AWS EC2 computing platform for this research. There are layers on top of the cloud computing infrastructure, such as the fintech blockchain service layer and the fintech blockchain core layer. The blockchain service layer is the layer that implements the identification and payment services. The blockchain core layer is the basic framework for the blockchain platform.

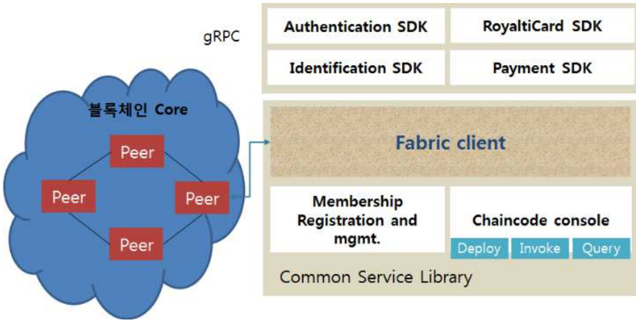

Fig. 4 Core and Common Service Library

Figure 4 describes the components of the blockchain core and common service library. We explain Figure 4 in two parts: the bottom half and the top half. In the bottom half, the fabric client operates distributed/decentralized communication primitives for achieving a P2P network, which is the basis of blockchain. The membership registration and management components are for managing the blockchain network for tasks that include the registration or resignation of members. Chaincode is a program written in Go or Java that implements a prescribed interface. Chaincode runs in a secured Docker container isolated from the endorsing peer process; it initializes and manages the ledger state through transactions submitted by applications. The bottom half is considered a common service library. The top half contains components that provide authentication, identification, payment, and royalty-card services. The royalty-card service represents point management or membership service.

B. Processing for Fintech Blockchain

It is too difficult to apply blockchain technology directly to fintech due to performance problems. For example, the Bitcoin blockchain requires 10 to 60 minutes until participants approve each block and a consensus as an authentic transaction record is built. The specific time required varies depending on the mining status in each block. In particular, when a block forks (multiple blockchains are created simultaneously), approximately 60 minutes are required to eliminate these forks. When a transaction was approved by participants as authentic, this is expressed as “a transaction was finalized,” and this process as a whole is called “finality.” The fact that a certain time is required for finality may restrict the application of Bitcoin to actual business. In actual Bitcoin transactions, the creation of the following six blocks is deemed as the finality of the relevant transaction, although it depends on the setting by wallet managers. Specifically, the processing performance for a transaction is as follows: approximately 5 transactions/sec on Bitcoin, approximately

25 transactions/sec on Ethereum, over 1000 transactions/sec on Hyperledger, and over 40,000 transactions/sec on Visa.

In order to resolve such a performance problem, we exploit the overlay network on payment processing for credit card payment platforms with blockchain. An overlay network is a computer network that is built on top of another network. Nodes in the overlay network can be considered connected by virtual or logical links, each of which corresponds to a path, perhaps through many physical links, in the underlying network. For example, distributed systems such as P2P networks and client-server applications are overlay networks because their nodes run on top of the Internet. The Internet was originally built as an overlay upon the telephone network, while today (through the advent of VoIP), the telephone network is increasingly turning into an overlay network built on top of the Internet. This is a type of off-chaining technique that originates from the off-loading technique. We will now describe how we implemented the credit card payment network in our research. For credit card payment processing, we use PayPal's payment platform.

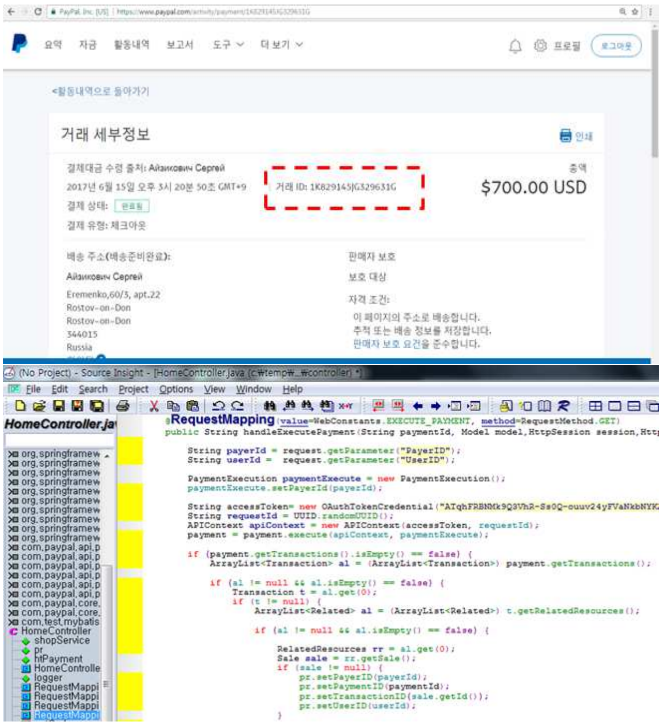

Fig. 5 Core and common service library

We checked the transaction details through the biometric transaction ID 1K829145JG329631G for this payment on PayPal's "transaction details" page. This study involves two ID values (Payment ID and Transaction ID) when a PayPal credit card transaction happens. In this study, the Payment ID is an internally used ID, and the PayPal system assigns the Transaction ID a unique value for each transaction. Therefore, although a processing delay is caused by the slow performance of the blockchain network, PayPal processes the payment through its credit card payment system. Then, the overlay network can check information about the sender of the payment based on the Transaction ID in the blockchain network for the PayPal credit card payment.

Table 1 represents the real mapping between Payment ID and Transaction ID. The transaction ID is a unique ID that is looked up when a user clicks on the detail view of an individual transaction in the PayPal administrator console. The payment ID is a unique ID assigned to individual transactions in the fintech blockchain platform developed in this study. These two IDs are associated for mapping onto an overlay network and are stored on a high-performance database.

TABLE I
IMPLEMENTATION ENVIRONMENTS AND DETAILS

ID types	Value
"Payment ID"	"PAY-5V487183H3120193CLE3VMNA"
"Transaction ID"	"78K009984J295715X"

Figure 6 shows the actual implementation of the payment system in this study. Hardware included a terminal computer, printing control board, credit card reader, and thermal receipt printer. The terminal computer is connected to the fintech blockchain platform through the Internet.

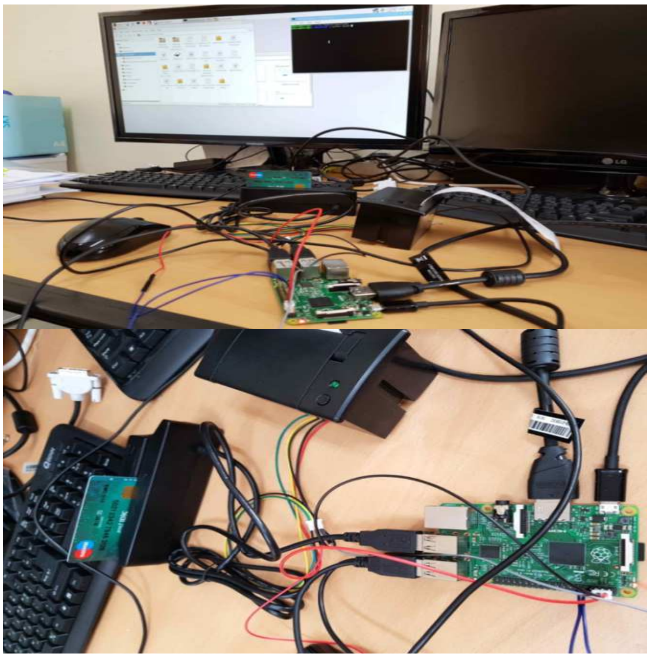

Fig. 6 Payment system implementation

The following configuration in Table 2 lists the parameter values applied in this study for driving the thermal receipt printer. Table 2 also lists the parameters that the control board for the thermal receipt printer is configured with. The control board and thermal receipt printer are connected by serial communication: RS232C, USB, etc.

TABLE II
IMPLEMENTATION ENVIRONMENTS AND DETAILS

thermal paper	50 ft	resumeTime	0.0
Voltage/current	5-9VDC, 1.5A	byteTime	0.0
Printing speed	50-80mm/s	dotPrintTime	0.033
Density	8dots/mm, 385dots/line	dotFeedTime	0.0025
Printing width	48mm	prevByte	'\n'
Character set	ASCII, GB2312-80	column	0
Font set	ANK:5X7, 12X24	maxColumn	32
Paper type	Thermal paper	charHeight	24
Paper width	57.5mm	lineSpacing	8

Paper roll diameter	Max 39mm	barcodeHeight	50
Protocol	TTL serial, 19200 br	printMode	0
Temperature	5-50 C	defaultHeatTime	60

In addition, the baud rate is 19200 bps and byteTime = 11.9 / float (boardrate). The name space for the thermal printer device driver is / dev / ttyAMA0, and the timeout value is 0.5 seconds. DotPrintTime was set to p / 1000000.0 microsec, and dotFeetTime was set to f / 1000000.0 microsec. The thermal line printer and the board were connected using the 22 AWG terminal shown in Figure 5 and connected to the Raspberry Pi controller board. The black line was connected to the ground, the yellow line to the data input terminal, and the green line to the data output terminal; the lines represent wiring connections for serial communication.

C. Database Model Design

In this research, requirements analysis and data modeling were performed. In addition, we designed and modeled the database through entity-relationship (ER) diagrams. An ER diagram is a way to display the relationships between entities and derivations of such entities from each task analysis in a diagram that is easy to understand. In actual projects, not only are the diagrams important, but so is the relationship between the flow of data and the processes in the task.

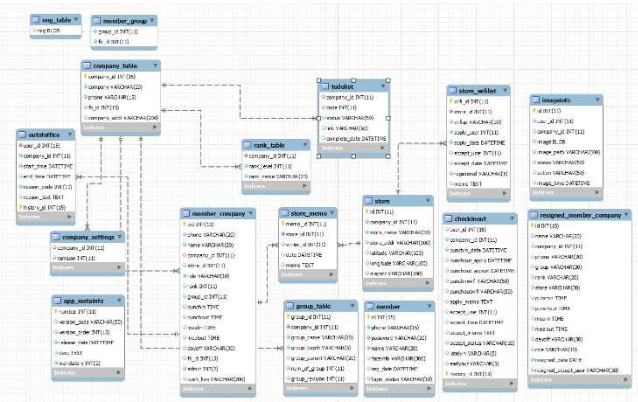

Fig. 6 Database schema designed

In object modeling using UML standard notation, drawing the class diagram that is most appropriate for the task is of the highest importance. In information-based modeling, the goal is to draw the most suitable ER diagram for the task. Because object modeling uses mostly relational databases, creating a data model that can build a database is a very important task in real projects. It was originally a theoretical work method to draw ER diagram when data analysis is finished to some extent (i.e., entity, relation, attribute, etc.) by analyzing data dictionary and various output products. It is expressed in the ER diagram and is always used as a core business output when communicating with internal project personnel or relevant business customers.

III. Results and Discussion

We now present the details of the data preparation, assessment metrics, and evaluation of our method. This section describes the experimental results for the fintech blockchain platform. Spring Framework is used as a standard platform for web application server construction. In addition, the server was built with an AWS-based cloud computing platform. The project management tool used in this study is Apache Maven. Maven is a tool that makes it easy to build a development environment through files in XML format.

TABLE III
Configuration and Versions for Software Components

Libraries	spring-context, spring-webmvc, jxl, spring-webmvc, spring-jdbc, spring-security-web, spring-security-config, spring-security-taglibs, tiles-core, iles-servlet, tiles-jsp, mysql-connector-java, mybatis, mybatis-spring, commons-dbcp, commons-net, commons-io, commons-fileupload, jackson-core-lgpl, jackson-mapper-lgpl, json-simple, commons-collections, aspectjrt, slf4j-api, jcl-over-slf4j, slf4j-log4j12, log4j, javax.inject, servlet-api, jsp-api, jstl, junit
International language support	org.springframework.context.support.ResourceBundleMessageSource org.springframework.web.servlet.i18n.CookieLocaleResolver org.springframework.web.servlet.i18n.LocaleChangeInterceptor

It is possible to obtain the effect of inputting and outputting through the database by calling functions on an object basis by Mybatis. We make use of the Spring Framework-based fintech blockchain management console developed in this study. We applied jQuery Mobile and CSS3 technologies as representations based on the HTML5 layout and introduced the client-side script through JavaScript. Various server technologies such as Spring Framework, Java, JSP, XML, JSON, Maven, and MyBatis were applied. Table 4 lists server performance indicators for each image size used for a representational state transfer (REST) API executed as a Chaincode application on the Hyperledger fabric platform. The number of samples was fixed at 100. The average response time, minimum response time, maximum response time, and standard deviation were described according to the processing of 100 sample images. The error rate was 0% in common, confirming that the service was properly performed. Throughput was approximately 83% to 91%.

Table 4 represents the request details regarding various content types such as text/html, text/css, JavaScript, and image. The largest downloading times were owing to JavaScript and jQuery. This is because, currently, most websites developed are dynamic. The time to the first byte is approximately from 234ms to 323ms.

TABLE IV
Configuration and Versions for Software Components

Label	**# of samples**	**Std. Dev.**	**Error %**	**Throughput**	**Avg. Bytes**
Upward (150X150)	100	9.88	0%	86.80556	1025
Transfer (150X150)	100	12.6	0%	85.10638	1372
Upward (200X200)	100	22.43	0%	87.87346	1025
Transfer (200X200)	100	21.97	0%	91.91176	1372

Label	# of samples	Std. Dev.	Error %	Throughput	Avg. Bytes
Upward (300X300)	100	33.09	0%	89.20607	1025
Transfer (300X300)	100	23.7	0%	82.71299	1372

This is because, currently, Internet communication is based on fiber to the home (FTTH). Therefore, the response time (the time to the first byte received) is the same for varying types of content. Figures 7, 8, and 9 show the performance in connection view.

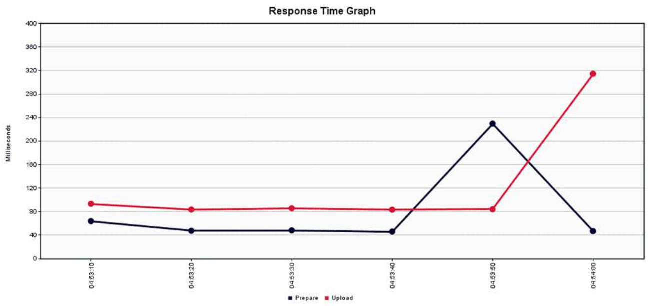

Fig. 7 Response time measured depending on the time elapsed

The red-colored plot represents the initial connection time. The black-colored bar shows the loading time of the contents. We can see that the most time-consuming part of our implementation is JavaScript and the images from Figure 9. This is because only those two components take more than one second for all content types.

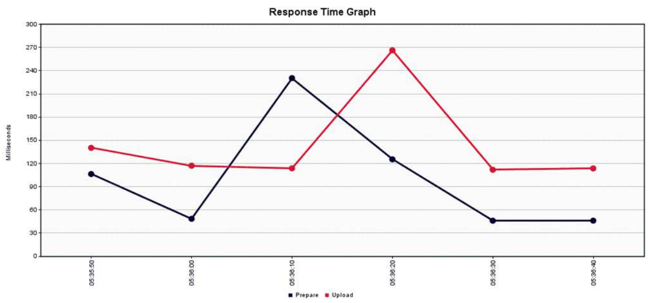

Fig. 8 Response time measured depending on the time elapsed

We can, in fact, see that if we increase the resolution, this may have negative implications on server performance. In places where Internet communication is slow, such as undeveloped countries, it is obvious that problems will arise when there are many concurrent users.

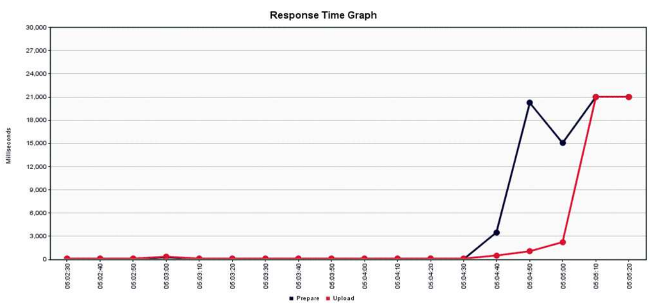

Fig. 9 Response time measured depending on the time elapsed

The experiment results below are based on a PC with an Intel Core i7 processor speed of 3.6 GHz and 4GB RAM. In the case of the 300X300, the response time is lower than the actual environment. According to the results in 12, when the service is provided, if the response time surpasses 21 seconds, then a timeout occurs. If 15,000 people are prepared to press the commission button, we must run at least 10 servers at the same time, however, this is not a linear relationship. This experiment shows the time taken to process 100 concurrent threads. As the number of concurrent access threads increases, the processing time tends to increase as shown in Figure 10

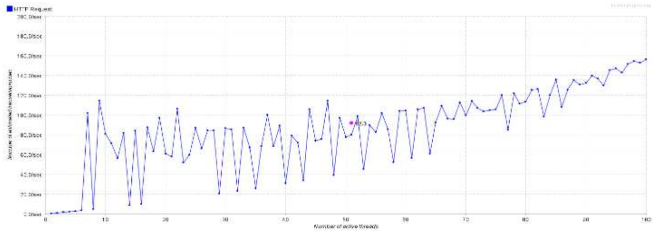

Fig. 10 Response time measured depending on time elapsed

The current consumption of the control board device for transmitting and receiving the communication transaction is approximately 8.2 mA. This is used to obtain the average current consumption over the entire connection section. We also consider control board current consumption while the device is in sleep mode. We found 0.001 mA are consumed in sleep mode owing to the characteristics of the board, therefore the power consumption can be obtained as listed in Table 5.

TABLE V
POWER DISSIPATION DEPENDING ON TRANSACTION INTERVAL

Interval (ms)	120	130	140	150	160	170
Avg. power dissipa-tion	0.1004239	0.0927759	0.0862204	0.0805391	0.0755679	0.0711815
Expected battery lifetime (time)	2290.2925	2479.093	2667.5807	2855.7564	3043.6208	3231.1746
Expected battery lifetime (days)	95.428854	103.29554	111.1492	118.98985	126.81753	134.63228

We achieved good power dissipation. If we set the communication interval of the control board to 170 ms, we can continuously use the system without charging the battery for up to 134 days (approximately four months).

IV. CONCLUSION

This paper describes a challenging study involving blockchain and fintech technology. Fintech is a new financial technology innovation aiming to compete with traditional financial methods to deliver financial services. This study was inspired by the question, "what if I could use Bitcoin (blockchain technology) with my credit card (fintech technology)?" We believe that such a scenario would result in the explosive growth of Bitcoin because of the convenience of use, as it would be equivalent to conducting a conventional credit card payment. If the fintech technology does not support Bitcoin, it is simply a "virtual" currency. Therefore, we implemented an integration between fintech and blockchain technologies in our study. Furthermore, we considered the platform in terms of performance. Even the performance of state-of-the-art blockchain technology cannot meet fintech application standards in the real world. In order to resolve performance issues with a blockchain network processing credit card transactions, we used the overlay network concept to separate the credit card network from the relatively slow blockchain P2P network.

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