

A Study on the Private 5G Frequency Allocation Process using NFT based on Smart Contract

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Abstract— The current Private 5G use procedure goes through the step of application examination, use and usage inspection. In order to apply for Private 5G, various forms of documents are required for the document review process and radio station inspection is required. For this reason, the procedure is complicated and takes a considerable amount of time until a Private 5G applicant uses Private 5G. In this paper, we proposed Frequency Allocation Process for Private 5G using a blockchain platform, which is fast and simplified than the current procedure.

Keywords—Blockchain, Frequency Allocation Process, NFT, Private 5G, RPA

I. INTRODUCTION

Recently, digital transformation has accelerated, many operators, regardless of specific fields, are paying attention to private 5G. Private 5G is a 5G network that can be used only in specific areas such as buildings and factories by operators, not mobile communication companies, and is an essential element for smart building and smart factory operations. Currently, Private 5G is undergoing complex procedures from frequency application to utilization management. These procedures can be broadly divided into four stages, which correspond to the application, review, utilization, and utilization management stages[1]. For allocating Private 5G frequencies, applicants must submit 10 types of documents like common carrier business registration application, business plan, frequency allocation application (agreement to provide Private 5G service, written oath), frequency usage plan (Entity details, major financial figures for the past 4 years) and etc. In the review stage, expert reviews are conducted on 8 items[2]. Even after allocation, cumbersome procedures such as on-site due diligence or frequency coordination, in which the dedicated agency directly participates, are necessarily required in the process of completion/regular inspection of radio stations. In this paper, we propose a blockchain platform for a faster and simpler RPA (Robot Process Automation) based Private 5G allocation process to address the rapidly growing Private 5G frequency demand. The proposed blockchain platform can use smart contracts for automate extensive and repetitive tasks included in the four-step usage procedure described above. In addition, security maintenance is essential for Private 5G as various types of operators, including public sectors such as military communications, participate. In this regard, this paper

presented a Private 5G frequency allocation process based on a block chain platform that maintains security for frequency use information between operators such as military, satellite, and telecommunications and provides mutual trust. Finally, by utilizing blockchain, it is possible to secure the reliability and integrity of data required throughout the use process.

II. PROPOSED PROCESS

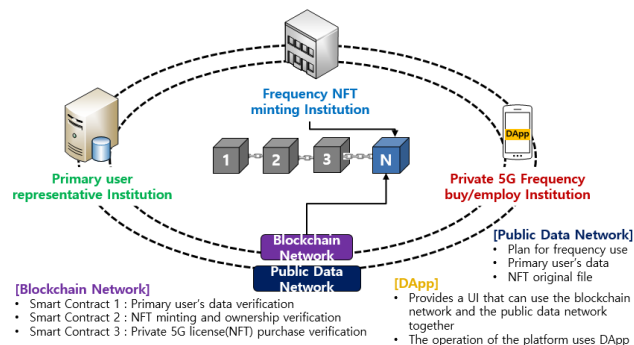


Fig. 1. Smart contract based frequency allocation process for Private 5G

Blockchain is a form of a distributed database platform. And non-fungible token (NFT) is a unique digital identifier that cannot be copied, substituted, or subdivided, that is recorded in a blockchain, and that is used to certify ownership and authenticity. In this paper, as shown in Figure 1, the Private 5G frequency allocation process is handled by smart contracts using the blockchain platform. By automating many of the manual procedures required for Private 5G frequency allocation, the Private 5G frequency allocation process can be operated more actively[3]. In addition, by utilizing a blockchain platform, we designed a Private 5G frequency allocation process that maintains security for frequency use information between multiple operators and is mutually reliable. Lastly, NFT was used to prevent the Private 5G license forgery problem[4].

The use of smart contract is absolutely necessary in the design of the Private 5G frequency allocation process[5], and transactions and verification between all institutions participating in the Private 5G frequency allocation process

are carried out only by smart contracts. In order to allocate Private 5G frequencies, institutions participating in the Private 5G frequency allocation process must participate in the Ethereum based blockchain network. The components and roles of each institution are shown in Table I. In addition, the proposed process operates according to the sequence of the process diagram described in Figure 2.

TABLE I. COMPONENTS AND ROLES OF THE FREQUENCY ALLOCATION PROCESS FOR PRIVATE 5G

Node	Role
Private 5G Frequency buy/employ Institution	Buy : Private 5G license(NFT)
	Preparation of frequency usage plan for use Private 5G
Frequency NFT minting Institution	Private 5G license(NFT) Minting and ownership transfer management
	Primary user's DB storage
Primary user representative Institution	Interference analysis
	Periodic update of radio station utilization information

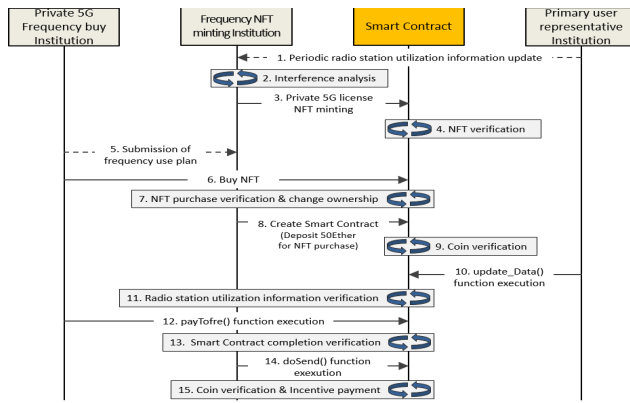


Fig. 2. Algorithm of frequency allocation process for Private 5G

The Frequency NFT minting Institution is designated as a national institution to secure reliability for the Private 5G frequency license. The Private 5G Frequency buy/employ Institution can avoid the cumbersome procedure of the current Private 5G frequency allocation process described in Table II through the proposed process.

TABLE II. COMPARISON OF THE CURRENT & PROPOSED PROCESS

Type	Current	Proposed
Application	1. Submit documents directly to the Ministry of Science and ICT	1. Submission of documents through DApp and verification of submission through blockchain platform
Review	1. Review through the review committee 2. Analysis through the National Radio Research Agency (RRA)	1. Automated reviewing through smart contract 2. Analysis through Frequency NFT minting Institution
Utilization	1. Application for permission to establish a radio station to Central Radio Management Service(CRMS) and	1. After the first radio station equipment inspection, automatic measurement of abnormality through radio

	submission of documents	station check equipment
Management	1. Submission of related documents after installation of radio stations	1. Inspection through radio station equipment status recorded in blockchain

In this paper, we coded in the Solidity language to use smart contracts in the Private 5G frequency allocation process, and managed the operation of the process by creating user defined functions as shown in Tables III and IV.

TABLE III. FUNCTION TYPES AND ROLES OF SMART CONTRACTS (NFT MINTING)

Function	Type	Role
create()	Minting NFT	Private 5G license (NFT) minting
transferFrom()	Change ownership of NFT	Change ownership of Private 5G license (NFT)

TABLE IV. FUNCTION TYPES AND ROLES OF SMART CONTRACTS (APPLICATION FOR PRIVATE 5G ALLOCATION)

Function	Type	Role
Pri_5G()	Create new smart contract	Create Private 5G allocation application smart contract
update_Data()	Update radio station utilization data	Periodic update of primary user's radio station utilization information
payTofre()	Behavior of smart contract	Check smart contract working without any problem
doSend()	Coin reward	Frequency allocation fee paid to Frequency NFT minting Institution

III. SIMULATION OF PROPOSED PROCESS

In this paper, in order to use the blockchain platform in the Private 5G, the frequency allocation process was simulated by classifying institutions as shown in Figure 3.

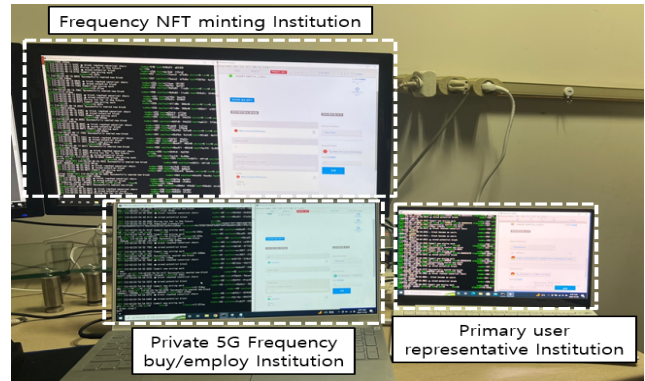


Fig. 3. Simulation environment

Throughout the process operation, Primary user representative Institution's radio station utilization information is updated periodically through the public data

network, and Frequency NFT minting Institution performs interference analysis based on the data received from Primary user representative Institution for minting NFT. Private 5G Frequency buy/employ Institution purchases the NFT corresponding to the place where the Private 5G frequency will be operated among the Private 5G license NFTs minted by Frequency NFT minting Institution. When the purchase is complete, the ownership of the NFT is belong to the Private 5G Frequency buy/employ Institution through the smart contract as shown in Figure 4.

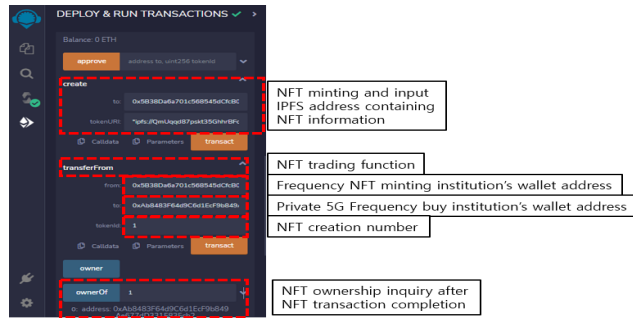


Fig. 4. Minting of NFT and Changing of ownership

Figure 5, 6, and 7 show the 8 to 15 step process of the Figure 4 algorithm. The smart contract is terminated after execution of doSend() function.

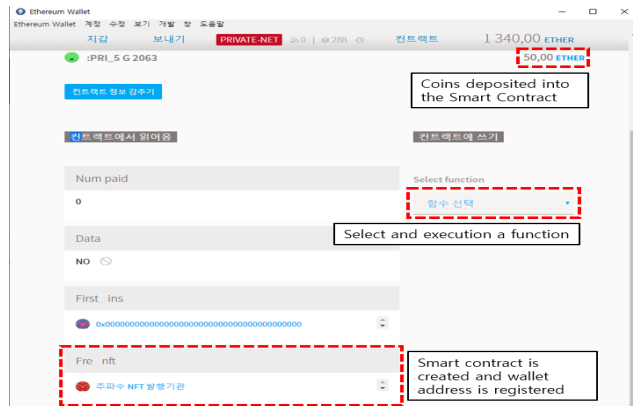


Fig. 5. Execution of Pri_5G() function

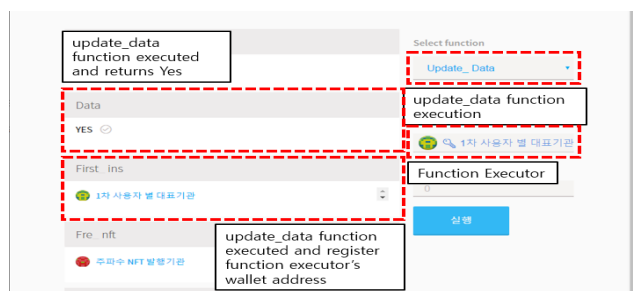


Fig. 6. Execution of Update_data() function



Fig. 7. Execution of payToFre() function

IV. CONCLUSION

In this paper, we proposed a Private 5G frequency allocation process that is faster and simpler than the current process and can achieve a higher level of security by using a blockchain platform. In addition, by applying the RPA system that can minimize the manpower required for the Private 5G frequency allocation process, the manpower consumed in the Private 5G frequency allocation process was reduced and fairness was secured in the frequency allocation process. Finally, reliability of Private 5G frequency allocation was secured through frequency licenses using NFT.

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