A Study on Utilization of Blockchain for Electricity Trading in Microgrid

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***Abstract*—The conventional electric power system is a unidirectional configuration that delivers electricity to the consumer in the power plant, but as the prosumers emerges, microgrid technology that enables bi-directional configuration has been developed. By applying the data distribution processing technology called the blockchain to the microgrid, time and cost can be saved compared with the conventional microgrid system. Through the related research, we analyze the structure of the microgrid and the utilization of the blockchain, study the pros and cons of applying the public blockchain and the private (consortium) blockchain, and propose the possible scenarios.**

Keywords— microgrid; public blockchain; private blockchain

I. INTRODUCTION

The microgrid system refers to a local power supply system centered on a distributed power source independent of the conventional wide power system[1]. As shown in Fig. 1, a number of prosumers, not only in the power plant, will take charge of the power generation of the grid based on the two-way transmission and distribution. It means to use distributed power sources such as renewable energy like solar power and wind power, cogeneration power generation, and fuel cell as their own power generation sources. As the power source is dispersed, it is possible to supply electricity stably and to efficiently transfer renewable energy[2].

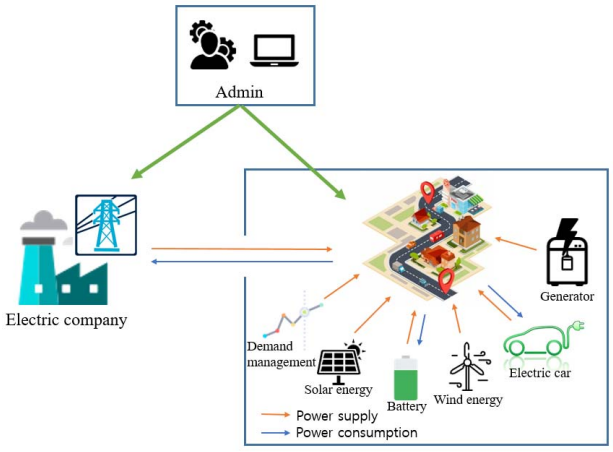

Fig. 1. Microgrid system

The blockchain refers to a technique of distributing data, that is, a technique in which all users participating in the network distribute and store data such as all transaction details. In the blockchain, transaction is gathered to create a hash of the block. In this case, the hash of the previous block is also included to affect the hash of the current block. This allows you to determine whether you are forged or tampered with. In the conventional business network, as shown in Fig. 2, all participants managed their own ledgers, resulting in conflicts arising from duplication and inconsistency, resulting in increased settlement time. On the other hand, using a blockchain-based shared lender allows the transaction to be validated through consensus and the transaction cannot be changed, company can save the time and reduce the money.

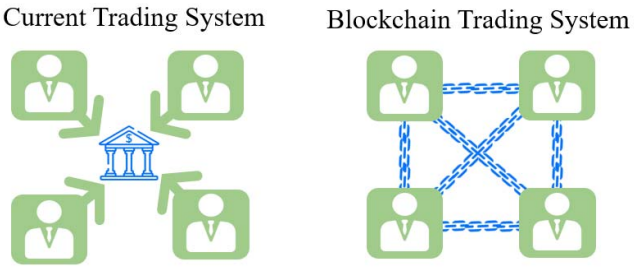

Fig. 2. Current trading system and blockchain trading system

In this paper, we study the most suitable blockchain protocols and types for constructing an efficient and transparent microgrid energy system.

The composition of this paper is as follows. We explain the ongoing research PowerLedger, Brooklyn microgrid, and Block charge in chapter2. In chapter 3, we apply blockchain to the microgrid system. Finally, we conclude in chapter 4.

II. RELATED WORKS

A. PowerLedger

PowerLedger developed and demonstrated an energy trading network in Australia's first P2P blockchain at Busselton in western Australia. The PowerLedger platform enables interoperability between various market management / pricing mechanisms and electrical units (kWh) through pre-purchased tokens, and controls market flexibility with dual token ecosystems (POWR and Sparkz). The POWR tokens allow application hosts and participants to use the platform, and Sparkz tokens are issued for escrowed POWR tokens via smart bonds and are used for ecosystem transactions. A sufficient number of POWR tokens must be maintained to generate the Sparkz required for the consumer's transaction, and the Sparkz tokens are priced and used in the platform currency of the platform participant.

2375-9356/18/$31.00 ©2018 IEEE
DOI 10.1109/BigComp.2018.00141

PowerLedger uses two kinds of blockchain hierarchy as shown in Fig. 3. First, at the public layer, utilize the ethereum blockchain to link the microgrid ecosystem with other token exchange. The other blockchain hierarchy was configured to enable energy trading within the application using PowerLedger's eco-chain, an industry-specific consortium blockchain.

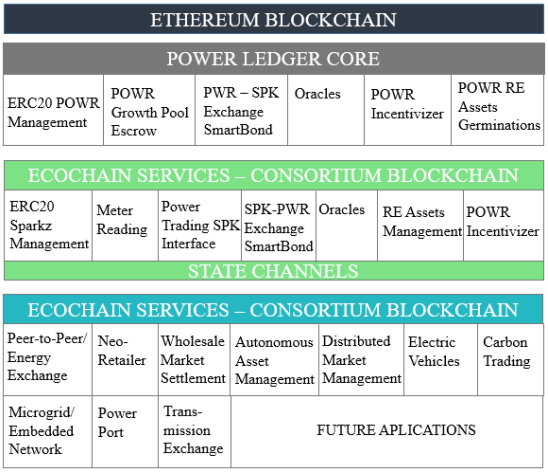

Fig. 3. Configuration of PowerLedger's blockchain

B. *Brooklyn microgrid*

The microgrid project in Brooklyn, New York is a system that enables neighboring electricity trading without relying on conventional electric power companies like Fig. 4. The solar panel-owned households (prosumers) produce electricity, and the other purchases electricity that is left unused by solar panel holders. Among them, a blockchain network manages and records electricity transactions between neighbor. On the presidential streets, households engaged in electricity trading among their neighbors are equipped with smart meters, so that they can confirm the electricity production and consumption. The blockchain network associated with these smart meters records transaction status so that any participant can see them. The ethereum platform is used as a blockchain network[5].

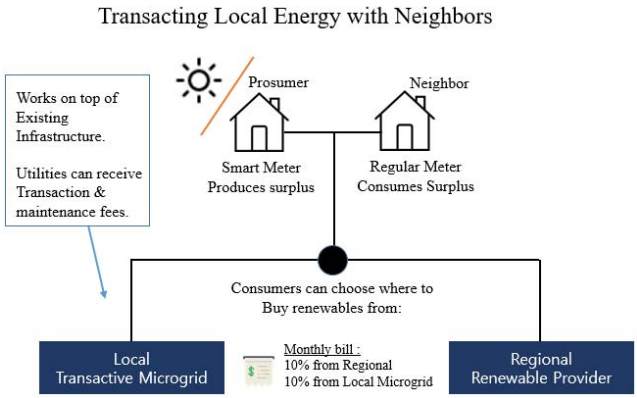

Fig. 4. Concept of neighborhood power trading

C. *EV charge payment system 'Block charge'*

German power company RWE has partnered with IT software company Slock.it to promote Block charge, a no-contract EV charging system. Block charge allows consumers to automatically manage charging and payment transactions through applications without relying on intermediaries. In addition, it is possible to manage the electric vehicle charging station infrastructure, prevent transaction risk, and expand the partner through open API. All transactions are managed using a blockchain-based system, and a simple and secure system is constructed using smart contracts[6].

As in the above study, the consumer and prosumer is making the microgrid system in the region without depending on electric power companies. In Chapter 3, we show how to use blockchain in microgrid.

III. BLOCKCHAIN IN MICROGRID

A. *A Study of blockchain extension platform*

First, there is an original blockchain used in the Bitcoin that is the first crypto currency, and ethereum added the concept of smart contract on the blockchain. In the case of original blockchain, there are many restrictions because it is not Turing completeness. Ethereum, on the other hand, has added the concept of smart contracts, making it easier for users to make contracts across platforms.

Smart contract is stored as byte code in the block chain as shown in Fig 5. Smart contracts are executed by stored transactions, and states reflecting the results are converted whenever a block is added. The conventional contract is in writing, so if you want to fulfill the contract conditions, the actual person has to carry out the contract, but if you create the contract using digital contract using smart contract, the technology will be able to automatically execute the contents according to the condition[7].

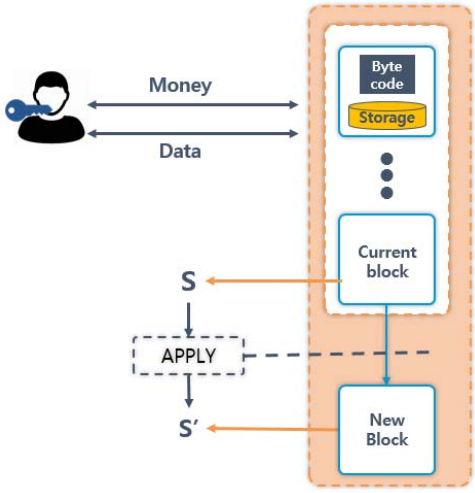

Fig. 5. Smart contract in blockchain

The conventional microgrid system is shown in Fig. 6. In order for prosumer and consumer to make a deal, it is a form of

requesting a match to an intermediary and then signing a contract for a certain period of time and trading electricity.

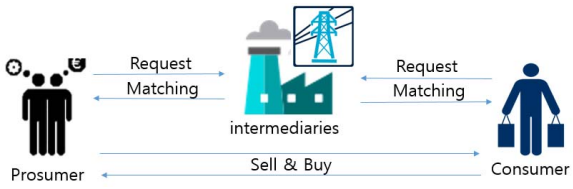

Fig. 6. Conventional microgrid system

By applying the ethereum platform to the microgrid, consumers and prosumers can create the desired contract using the smart contract without intermediary intervention. After the contract is created, the contract can be executed if the conditions of the transaction are satisfied.

B. *Application of blockchain types*

The blockchain is divided into public and private blockchain according to the characteristic of the participant. A public blockchain can be created by anyone and can be read by anyone. Therefore, it takes a long time to share blocks on the Internet. Also, when many blocks are generated at the same time, it is difficult to select one block, so that the block generation time is limited (0.02ktx/sec or less) In contrast, the private blockchain can only generate blocks for authorized users, and transaction validation is only available to authorized users. Therefore, network expansion and service speed(1ktx/sec or more) are fast[8].

a) Public ethereum: Between prosumers and consumers, the public ethereum platform allows anyone to browse blocks, and anyone can trade and verify. But even those who are not directly involved are slowing transactions because they have to validate and archive transactions. In addition, prosumers need to update the smart meter regularly, but there are many problems because of the block verification and generation speed. For this reason, public ethereum is not effective in direct transactions with consumers and prosumers. However, PowerLedger can be used to publicly exchange or store coins to be used in contracts using a public blockchain as shown in Fig. 7.

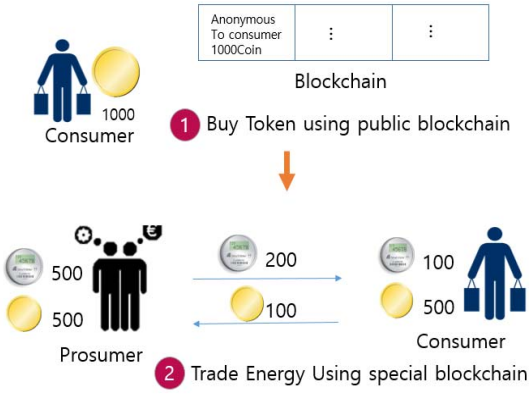

Fig. 7. Trade electricity using two blockchain

b) Private ethereum: With the private blockchain, people who are able to produce electricity using solar panels form the blockchain. In addition, the protocol can be changed through agreement of the members, so it is possible to update periodically. The scenario is shown in Fig. 8.

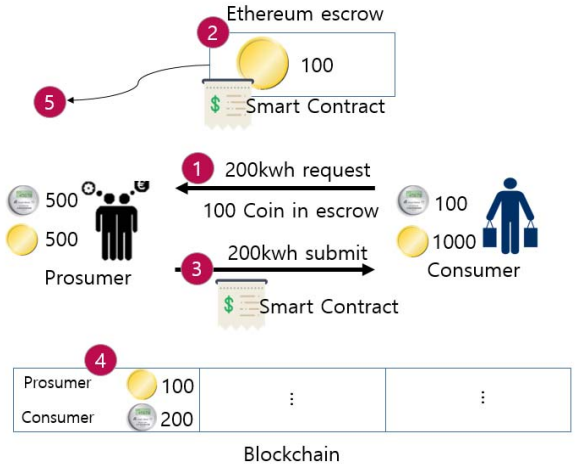

Fig. 8. Consortium ethereum scenario

First, the prosumers periodically updates his smart meter and adds it to the block. Consumer can always see the prosumer's surplus power through the app. ① Consumer uses smart contract to request 200kwh from prosumer and ② 100 coin to ethereum escrow. ③ Prosumer also generates a transaction that transmits 200kwh using smart contract. ④ The transaction is put on the blockchain and the block is verified. ⑤ After completing the verification, consumer will receive 100 coins saved in escrow.

As a result of applying microgrid system according to the characteristics of blockchain, ethereum platform using smart contract was most appropriate. As shown in TABLE I, a private blockchain that enables consumers to generate transactions and guarantee a high speed is studied to be applicable to the microgrid system.

TABLE I. CHARACTERISTICS ACCORDING TO KINDS OF BLOCKCHAIN

	Public	Private
Verification	Everyone	Prosumer
Constructor	Everyone	Prosumer, Consumer
Storage	Everyone	Prosumer, Consumer
Role	Change token	Trade electricity using token

IV. CONCLUSION

In this paper, we analyzed two kinds of blockchain platform and microgrid system according to the type of blockchain. By applying a private blockchain platform to conventional microgrid systems, it is possible to use smart contracts and construct transparent and efficient systems. In

addition, the ethereum platform can be applied to real estate systems as well as electric power fields.

Future researches need to design an actual private blockchain and a public blockchain that can operate the microgrid system and compare the pros and cons of the blockchain.

ACKNOWLEDGMENT

This research was supported by the MSIT(Ministry of Science and ICT), Korea, under the ITRC(Information Technology Research Center) support program(IITP-2017-2015-0-00403) supervised by the IITP(Institute for Information & communications Technology Promotion).

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