

Examining the Applicability of Blockchain to the Smart Grid Using Proof-of-Authority Consensus

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INTRODUCTION

- Bitcoin was the first use case of blockchain and was proposed by Satoshi Nakamoto.
- The blockchain has been an essential tool used in various fields especially in finance and real estate through the use of smart contracts.
- Ethereum smart contract is the first working smart contract.
- Smart contracts are computer programs or transaction protocols which are intended to automatically execute, control or document legally relevant events and actions according to the terms of a contract or an agreement.
- With increasing activities on in the Power grid, security of the smart grid is now paramount as it has faced cyber-physical attacks.
- The blockchain proof-of-authority will be able to achieve enhanced grid security especially in energy trading without compromising scalability.

BLOCKCHAIN CONSENSUS

- Blockchain consensus is a way that the blockchain systems achieve necessary agreement on a single data value or a single state of the network among distributed processes or multi-agent systems.
- There are lots of blockchain consensus which includes, proof-of-work, proof-of-stake, proof-of-capacity, proof-of-authority and so much more.
- Proof-of-authority(PoA) consensus mechanism was adopted in this project because it can solve the blockchain trilemma which is achieving scalability without compromising security and decentralization.

PROOF OF AUTHORITY(POA) CONSENSUS

- PoA is a reputation-based consensus algorithm that provides a practical and efficient solution for blockchains.
- The PoA algorithm leverages on the value of identities, which means that block validators are not staking coins but their own reputation.
- The process of becoming a validator requires scrutiny and rigor and, therefore, it is a difficult task to try to compromise the network as validator's reputation and identity is at stake and can be prosecuted.
- PoA blockchains are secured by the validating nodes that are arbitrarily selected as trustworthy entities.
- The PoA model relies on a limited number of block validators and this is what makes it highly scalable and thus suitable for mainstream adoption.

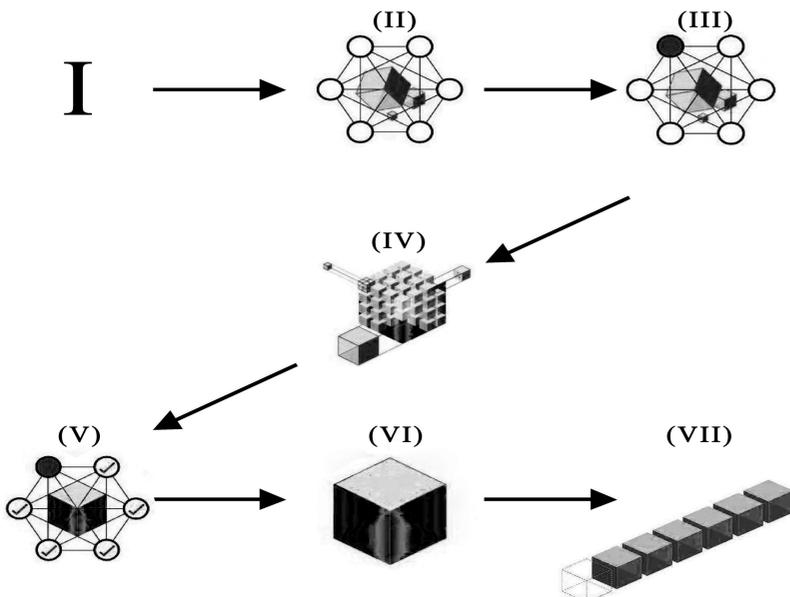


Figure 1. Adding a block to the blockchain using PoA consensus.

Figure 1 illustrates how a block is added to the blockchain using the Proof of Authority consensus mechanism.

- In stage I, users and smart contracts initiate transactions, which are submitted to the network on an ongoing basis.
- In stage II, a P2P network of approved validators continually receives transaction requests for inclusion in the next block.
- In stage III, an algorithm assigns one validator node as primary.
- In stage IV, the primary validator node assembles transactions into a block and confirms its validity.
- In stage V, the remaining validator network confirms the primary node block.
- In stage VI, with consensus achieved, the Energy Web Chain is updated with a new block.
- Finally, in stage VII, the confirmed block is added to the chain of blocks (blockchain). Note that this process above requires less computational power as consensus is reached by a group of validators.

PROPOSED PEER-TO-PEER ENERGY TRADING ARCHITECTURE

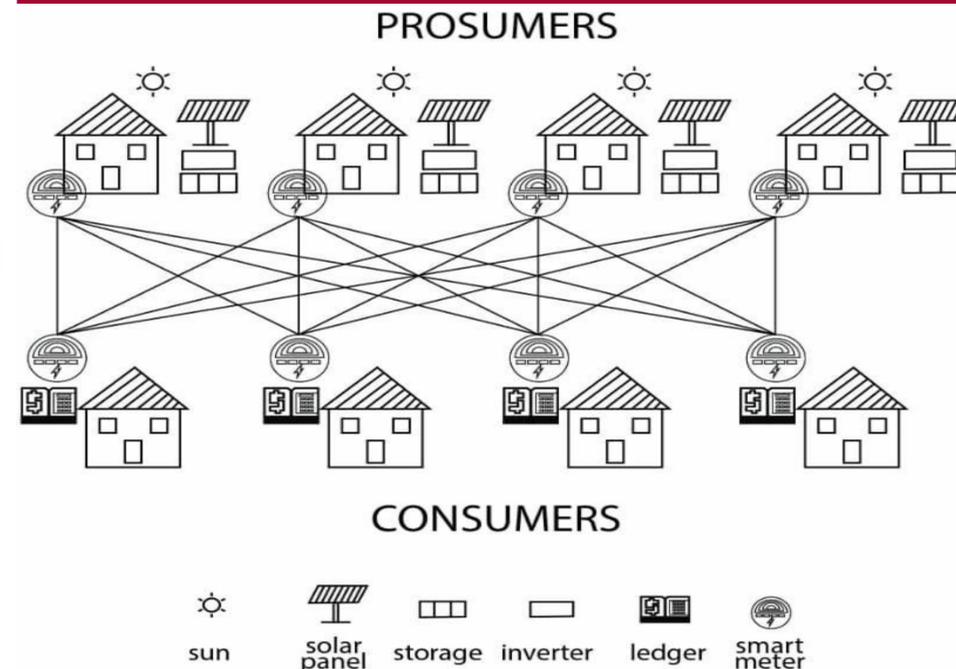


Figure 2. Peer-to-Peer (P2P) Energy Trading Architecture.

- Figure 2. below shows how the energy is trapped from the sun using the solar panels and then stored (in batteries) after which the stored energy (DC) is then converted to AC with an inverter before the prosumers can be able to either utilize or resale to their various consumers.
- There is a presence of a smart meter that measures the amount of energy generated, used and transmitted to other customers.
- The presence of the distributed ledger is important to aid the P2P energy transactions between the prosumers and the consumers and to ensure that the transactions are been validated by validators before they are added to the blockchain.

REFERENCES

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ENERGY TRADING FLOW CHART

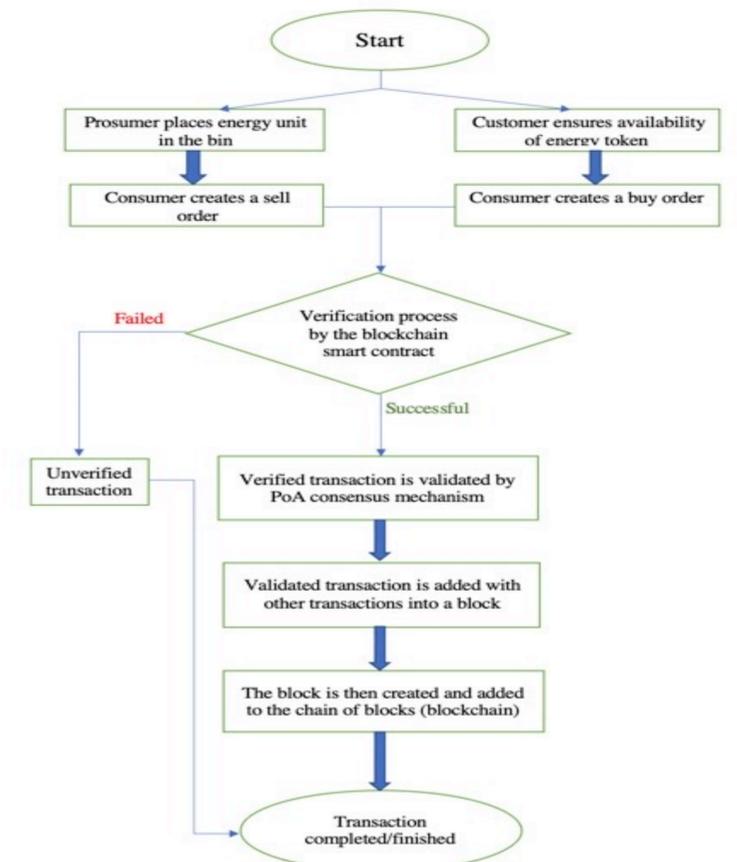


Figure 3. Peer-to-Peer (P2P) Energy transaction flow process

- Figure 3. above shows a successfully completed P2P energy transaction,
- Prosumer places generated energy units are stored in the bin where the smart contract can access it. On the other hand, the consumer ensures availability of energy token.
 - Prosumer initiates a sell order for certain amount of energy, while consumer already has an equivalent amount of energy token to use for the purchase; consumer initiates a purchase order.
 - The transaction is verified by the blockchain for REC and legitimacy using the smart contract. Transactions at this stage can either be successful or unsuccessful.
 - Successful transactions are validated by the Proof-of-Authority (PoA) consensus mechanism and unsuccessful transactions are eliminated.
 - Successfully validated transactions are added with other transactions into a block.
 - The block is then created and added to the already existing chain of blocks (blockchain) and, at this time, it is immutable as it cannot be altered, while declined transactions are eliminated.
 - The peer-to-peer energy transaction is now completed, and both the prosumer and the consumer are notified of the result of the transaction.

CONCLUSION

- This research analyzed the applicability of the blockchain to the smart grid using PoA consensus mechanism.
- The PoA can aid in the mainstream adoption of blockchain in the smart grid as it provides scalability that other consensus mechanisms cannot provide.
- This study concluded that the blockchain can be suitable for the smart grid especially in the provision of security and faster transaction authentication which can be achieved with the help of PoA consensus mechanisms.
- The blockchain cannot be successfully applied to the power grid unless there is a harmonization between the government and private participants as many power systems around the world are still heavily regulated.