Block Chain for Smart Grid

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Abstract— A community which is a collection of groups of family living houses. Each house generates many wastes water due to washing, bathing, cleaning, etc. Those all water other than sending to drainage we can divert them through pipelines into a huge tank. We can use this water for electricity by purifying the water. Transaction between water flow to turbines, amount of power generated, consumers power usage are verified and recorded in blocks. This paper proposes block chain as a tool.

Transactions as performed with smart contracts and the network act as transaction verifier. It also provides immutability to transaction history, which can be used for audit or solving a transaction dispute. In this, we include sensors for each house to know the quantity of water released and to know the quantity of electricity to pass without adding extra cost. If any amount of extra electricity need to be passed we cost them according to it. As every house doesn't have the same amount of wastage water so at the end of every day the remaining water can be sent to gardening or path side trees to be grown.

Indexed Terms-- Smart grid, blockchain, decentralization.

I. INTRODUCTION

In the past few decades, traditional centralized fossil fuel-based energy systems have been facing some major challenges such as long-distance transmission, carbon emission, environment pollution, and energy crisis. In order to build a sustainable society by addressing these challenges, utilization of renewable energy from diverse sources as well as improving the efficiency of energy usage are the two key potential solutions. In recent years, the smart grid concept which involves communication technology, interconnected power system, advanced control technology, and smart metering has been applied to improve the utilization of renewable energy sources and relieve the energy crisis somehow. The concept of smart grid has been introduced as a new vision of conventional power grid which offers two-way energy and information exchange in order to figure out an efficient way of delivering, managing, and integrating green and renewable
energy technologies.

Unfortunately, the smart grid makes it difficult to enhance the access to distributed and scalable energy resources at a large scale as well as ensure energy security and integrate other approaches to improve the energy utilization efficiency and reliability. Therefore, in order to advance it and solve the current limitations, the Energy Internet (EI), also called Internet of Energy (IoE) or Smart Grid 2.0, has been introduced by integrating smart grid context with Internet technology. In contrast with the smart grid, the EI is an Internets tyle solution for energy related issues by accommodating with IoT, advanced information & communication technologies, power system components, and other energy networks. The aim of this emerging and innovative approach is to ensure the connection of energy anywhere at any time. In summary, both concepts have been developed with aims to ensure that all the participants and components have the ability (i) to interact closely with each other, (ii) to make decisions by themselves, (iii) to exchange both energy and associated information in multiple ways, (iv) to access large-scale different types of distributed energy resources seamlessly, (v) to adapt with both centralized and distributed energy sources, (vi) to balance energy supply and demand through energy sharing, and (vii) to ensure flexible energy generation/selling and purchasing or consuming the energy. Since the connectivity is becoming larger, a major challenging issue is to integrate and coordinate a large number of connections such as growing distributed energy producers, their consumers, electric vehicles, smart devices, and cyber-physical system within the traditional centralized grid system. Managing such continuously growing network in a centralized manner will require sophisticated and costly information & communication infrastructures. Thus, moving towards decentralization is a trend in smart grid so that all its components can incorporate and integrate in adynamic way. Also, decentralization is one of the fundamental requirements in the EIs development happening in smart grid according to its vision.

II. BLOCKCHAIN

Blockchain represents a cryptographically secure distributed digital ledger over a P2P network of computing devices and systems. Blockchain is also defined as a distributed data structure whereby all data items are permanently recorded after they are verified by majority of the nodes in P2P network. The key components of a blockchain system include: 1)linked linear data structures to incrementally append data items (termed as transactions) in existing valid blockchains, 2) cryptographic algorithms to generate hashkeys to anonymously access the data items on the blockchain,3) consensus algorithms to ensure the validity of changes in already stored data, and 4)message passing protocols to enable P2P communication over underlying network. Blockchain technologies use variety of consensus algorithms such as proof-of-work , proof-of- stake , proof-of activity, proof-of-authority , proof-of-burn ,Byzantine fault tolerance , proof-of-elapsed time, proof- of-capacity, proof-of-importance,. We had reviewed and presented the above- mentioned consensus algorithms in our previous work We observed that proof-of-work is dominantly adopted by current blockchain based technologies, mainly cryptocurrencies but other consensus algorithms were also implemented by various early adopters of blockchain technologies.

Proof of Work (PoW): The PoW is the first public blockchain consensus which is introduced in Bitcoin. The main idea behind this mechanism is that in order to create a new block, the consensus nodes are asked to solve a computationally expensive puzzle, known as PoW problem which is hard to solve but easy to verify. Once solved, the solution is attached to the new block, and it broadcasts across the network. This attachment allows any other nodes to verify the correctness of a new block published by the particular node. Here, the processing is also called mining, and usually, it is incentive based. However, though the target of the PoW is to try to avoid different kinds of cyber-attacks, it is also vulnerable to 51% attack where one or a group of malicious nodes may take control of 51% of processing power in the blockchain network. Additionally, the mining process of PoW introduces some drawbacks such as inefficient throughput, high latency, and high energy consumption that make PoW unsuitable for many other blockchain applications.

Proof of Stake (PoS): The PoS is the most popular alternative mechanism of PoW which aims to improve upon PoWs common limitations. In PoS-based blockchain, the term mining is replaced by validating, i.e., blocks are commonly validated rather than mined. The concept behind PoS is that the algorithm randomly determines the validators to create the new blocks, and the probability of a node validating the next new block is proportional to the stakes/assets (e.g., coins) in towns. In other words, instead of running high computational puzzle-solving, in PoS, the validators need to prove its share in the network according to the current chain. The PoS is implemented in. However, the wealthiest validators may be the ones administering the blockchain which makes the PoS mechanism unfair. To overcome this, in, the authors consider stake age into consideration. The validators having the oldest and largest assets would be more likely to validate a block.

Proof of Activity (PoAc): The PoA consensus mechanism is developed based on PoW and PoS. The block creators of the next new blocks in the blockchain initially work as miners using PoW mechanism to defence security attacks, and hence, they start to receive the rewards. Once the miners has enough coins (asset), they move to utilize the PoS.

Proof of Burn (PoB): The PoB is an alternative of both PoW and PoS. The PoB allows the validators to create a new block and get rewarded once they burn their own coins/assets by delivering to verifiable, public, and un-spendable addresses. This spending coin is considered an investment. Hence, after investing, a user can make their stakes on the chain and become an authorized validator. In contrast with PoW and PoS, The PoB does not require energy consumption. The Slim coin is developed based on PoB.

Proof of Elapsed Time (PoET): The PoET is designed by Intel for permissioned blockchain applications in order to address the challenges of expensive investment of energy in PoW. Based on the trusted enclave in Intels Software Guard Extension (SGX), the computational expensive works are replaced with the proof of elapsed time. PoET uses a trust detection model among the entire population of the validators , where it randomly chooses the next leader to publish the block. The validators in network request for a random wait time from their enclaves. The validator having the shortest waiting time for a particular block is elected as the leader, and it needs to wait until after the waiting time had expired to publish the new block. The trust is established in the hardware that produces the time. The Hyper ledger Sawtooth is based on PoET.

Proof of Authority (PoA): The PoA is designed particularly for permissioned blockchain. According to the mechanism, before becoming an authority to publish a block, the participant has to confirm its identity in the network. Unlike PoS, instead of having some coins/other assets, PoA considers a participants identity as a stake. Moreover, it is assumed that the authorities are pre-selected and trusted to publish a block. Also, it is convenient to detect the malicious authorities and inform about the malicious activities to other nodes. The Parity Ethereum is developed based on PoA.

Practical Byzantine Fault Tolerance (PBFT): The PBFT provides a solution to the Byzantine Generals Problems for the asynchronous environment. PBFT works on the assumption that at least two-thirds of the total number of node share honest. It involves the following phases.(i). A primary node is selected to become a leader in was proposed. The concept enables a small, order to create and validate a block. The primary node can be changed by the rest of the nodes in the network, and the selection is also supported by more than two-thirds of all nodes.(ii).After receiving a request from the user, the leader generates a new block which is considered as a candidate block.
(iii). The leader broadcasts the block to other nodes who are able to participate in consensus for verification as well as auditing.(iv).After receiving, each node audits the block data and broadcasts the results with a hash to other nodes. The audit results are compared by the nodes with others. (v). The nodes reach a consensus on the candidate block and send a replay back to the leader which consists of audit and comparison results.(vi). Once the leader receives the results from at least two thirds of the nodes agreed on that candidate block, the leader can finalize the block to include in the chain.

III. LITERATURE REVIEW

[1] Based on the diffusion of blockchain technology in the smart grid, this paper studies the framework and application of the blockchain technology in the smart grid, so as to combine the blockchain with the smart grid and establish a sustainable supply chain. However, the establishment of a sustainable supply chain is based on a layered theoretical framework. Not only should the framework take into account needless attributes and the relationship among various criteria and aspects but the application should also involve a balance of multiple stakeholders. For the above reasons, this paper uses a combination of Fuzzy-DEMATEL and ISM. (e results show that (1) the hierarchical path of sustainable supply chain management of the smart grid under the blockchain starts from the social level, pays attention to system construction, grasps the technical standards, and defines the development goals of the power grid. (2) (e- development of green energy has become a new market growth point. (3) (e control of the operation level becomes the focus of the smart grid. (4) (e optimization and development of the economic structure are restricted by social factors. By integrating and optimizing the blockchain and supply chain, this paper puts forward a theoretical framework, establishes a sustainable GIP application system with multi stakeholder participation at the supply chain level, and indicates the significance of the blockchain in the smart grid [2]. The demand for electricity increases rapidly along with the advancement of the industrial age. To ensure efficient distribution of the electricity, maintain low losses and high level of quality, and the security of electricity supply, the smart grid concept was proposed. The concept enables a small, individual scale to generate electricity and sell

it to the grid. However, the concept adds complexity to the existing system, such as how a transaction between these generators and consumers are conducted, verified and recorded. This paper proposes the blockchain as a tool to manage transactions in the smart grid. Transactions are performed with smart contracts, and the network acts as a transaction verifier. The blockchain provides immutability of the transactions, which ensure every transaction between generators and consumers will always be executed. It also provides immutability to transaction history, which can be used for audit or solving a transaction dispute. [3] Blockchain technology is showing a significant potential to disrupt a number of information technology domains. One of the especially interesting areas for blockchain applications is smart grid. A number of early papers have been published in this area, however, there is no systematic analysis of the impact of blockchain technology on decentralization of smart grids. In this paper, we analyze the standard NIST conceptual model of smart grid domains with respect to the three critical blockchain features: decentralization, trust and incentive. We integrate our findings in order to produce a fully decentralized blockchain-enabled smart grid considering NIST conceptual model. The results of this paper should help smart grid developers and researchers to obtain a conceptual reference of the overall applicability of blockchain technology in smart grid domains and sub- domains. In addition, this research will help to identify and guide smart grid blockchain development and research initiatives.

[4] The concept of smart grid has been introduced as a new vision of the conventional power grid to figure out an efficient way of integrating green and renewable energy technologies. In this way, Internet-connected smart grid, also called energy Internet, is also emerging as an innovative approach to ensure the energy from anywhere at any time. The ultimate goal of these developments is to build a sustainable society. However, integrating and coordinating a large number of growing connections can be a challenging issue for the traditional centralized grid system. Consequently, the smart grid is undergoing a transformation to the decentralized topology from its centralized form. On the other hand, blockchain has some excellent features which make it a promising application for smart grid paradigm.In this paper, we aim to provide a comprehensive survey on application of blockchain in smart grid. As such, we identify the significant security challenges of smart grid scenarios that can be addressed by blockchain. Then, we present a number of blockchain- based recent research works presented indifferent literatures addressing security issues in the area of smart grid. We also summarize several related practical projects, trials, and products that have been emerged recently. Finally, we discuss essential research challenges and future directions of applying blockchain to smart grid security issues.[5] With the integration of Wireless Sensor Networks and the Internet of Things, the smart grid is being projected as a solution for the challenges regarding electricity supply in the future. However, security and privacy issues in the consumption and trading of electricity data pose serious challenges in the adoption of the smart grid. To address these challenges, blockchain technology is being researched for applicability in the smart grid. In this paper, important application areas of blockchain in the smart grid are discussed. One use case of each area is discussed in detail, suggesting a suitable blockchain architecture, a sample block structure and the potential blockchain technicalities employed in it. The blockchain can be used for peer-to-peer energy trading, where a credit-based payment scheme can enhance the energy trading process. Efficient data aggregation schemes based on the blockchain technology can be used to overcome the challenges related to privacy and security in the grid. Energy distribution systems can also use blockchain to remotely control energy flow to a particular area by monitoring the usage statistics of that area. Further, blockchain-based frameworks can also help in the diagnosis and maintenance of smart grid equipment. We also discuss several commercial implementations of blockchain in the smart grid. Finally, various challenges to be addressed for integrating these two technologies are discussed.[6] The Smart Grid (SG) concept presented an unprecedented opportunity to move the energy sector to more availability, reliability, and efficiency to improve our economic and environmental conditions. Renewable energy sources (Solar & Wind) are such technologies that are used in the smart grid to figure out the environmental and economic issues and challenges. Smart grids provide energy in different crowded sectors with efficient and timely transmission of electricity. But the traditional power grids follow a centralized approach for energy

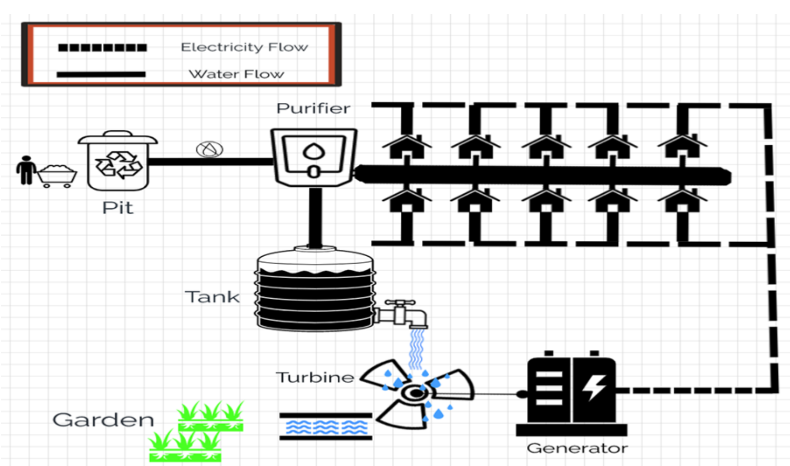
transactions with a large number of growing connections and become more challenging to handle power disturbance in the grid. Blockchain as a decentralized and distributed technology provides promising applications in the smart grid infrastructure with its excellent and salient features. In this Paper we have provided a concise review of the blockchain architecture, concepts, and applications in smart grids. Different potential opportunities for blockchain technology with smart grids are also discussed. Some future directions concluded the paper [7] This work investigates the unified coding and identifcation of smart grid IoT devices, as more and more IoT devices in smart grid need to be managed and controlled. We combine blockchain technology with 5G MEC to realize the connection of massive power IoT devices at the edge of 5G network. Due to blockchain's distributed storage and credibility, it is used to identify and register IoT devices in smart grid, ensuring the reliability and accuracy of smart grid IoT devices management. In this paper, we propose a hybrid blockchain mechanism based on 5G MEC smart grid, where both public blockchain and private blockchain are deployed on the MEC gateway/server. To facilitate the data searching and extracting, we endeavor to build a blockchain explorer indexed by IoT device identifer. After that, we study the typical consensus algorithms in the blockchain such as PoW, PoS, DPoS, PDFT, and discuss their feasibility in the hybrid blockchain. Finally, we analyzed and compared the performance of different consensus algorithms from the perspective of average computing time and average time to agreement.

IV. BLOCKCHAIN CATEGORIES

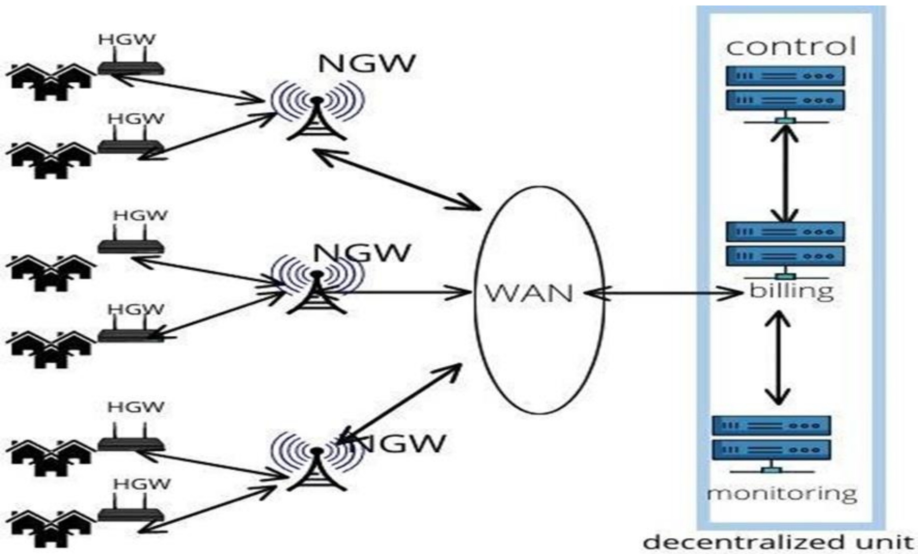
Permissioned vs Permissionless: Based on how blockchain is restricted to participate in creating new blocks and access the block contents, they can be permissioned or permissionless. In permissionless chain, anyone can join the blockchain network and engage in creating a new block. On the other hand, in permissioned chain, only pre- defined and authorized nodes can do this.

Private vs. Public: Blockchain can also be categorized as public and private. The public blockchains are truly decentralized and permissionless. They allow open participation and maintaining a copy of the chain by anyone. Usually, this type of blockchain has a large number of anonymous users. In contrast to the public chains, in the private blockchains, some selected/pre-defined and trusted users are permissioned to validate and participate in publishing the new blocks. Other public or permitted users in the network are restricted to read the data in the blocks. Unlike the public, the private chain may be partially decentralized. Furthermore, another type of private chain is named as consortium or federated blockchain which is also a permissioned chain. In this type of blockchain, a number of organizations make a consortium to maintain the blockchain and allow it to ensure transparency among the participants. Though, the private blockchain is still a centralized network, this kind of blockchain is usually developed to control by an organization and also, to increase the throughput.

V. EXTERNAL ARCHITECTURE OF SMART GRID



VI. Internal working of Block chain for smart grid



VII. COMPONENTS

Human Resources**:**

- To fix the pipes, electric wire.
- Monitoring & controlling.

Hardware**:**

- Power paid smart meters.
- Nan network.
- NGW & HGW.

Software**:**

- Hyper ledger fabric

CONCLUSION

In this paper, the applicability of blockchain technology in standard NIST conceptual model smart grids domains was presented to help identify and guide the decentralization of the smart grids. First, we identified key smart grid sub domains that can be enhanced using blockchain technology with respect to three critical blockchain features: decentralization, trust and incentive. Second, the application of blockchain in each of the domains was evaluated based on the three aforementioned criteria and the existing research in the literature. Finally, we identified key priority areas in each domain and specified a decentralized blockchain based version of the NIST conceptual model. The critical future research should be the analysis of blockchain impact on the costs and efficiency of smart grid operations. Within each selected domain, it is important to identify the concrete technical issues and challenges. Some of these might show significant inefficiencies with respect to the achievement of the core requirements of trust, decentralization, and incentive, and in turn demonstrate potential superiority of centralized approaches in some cases.

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