International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Using Blockchain Technology in Smart Grids and an Example Application

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Abstract: ***Today's power systems have been established in accordance with the design principles of Tesla, which was developed in the 1880s, and have evolved over time to become present. Despite the rapid development of communication technology, the development of power systems has not been able to keep up with this. Because the structure of the power system used has generally been far behind and has not been able to respond to the needs of the 21st century. With the rapid development of today's technology, it has become possible to make better the electricity grid by utilizing computer and network technologies in electrical networks. In this way, electricity networks will provide two-way information and electricity flow to provide consumers with sustainable, safe and uninterrupted energy. Networks that can do this are called smart grids. Blockchain; It is an operating system that creates precise and accurate records using mathematical functions and defines transactions in a decentralized infrastructure through distributed computer systems. Thanks to this system, there is no need for control, approval and reconciliation process by a central authority. Blockchain provides independent verification of all kinds of information to protect business processes from fraudulent and unbreakable features. Because this structure offers a digital recording notebook technology that everyone in the process can watch but never change. The use of Blockchain technology in smart grids is very important for the modernization of the network. Because of a possible downtime, the failure monitoring process can be faster and safer with Blockchain. By communicating more quickly between smart grid elements, companies can be informed more quickly in case of breakdown or downtime. It can give advice which devices are needed to convert the system back to normal, the repair process can be faster and quicker. In this study, the usability of Blockchain technology in smart grids is investigated and detailed.***

Keywords: Blockchain, Smart Grids, Cyber Security

1. Introduction

Nowadays, the use of information technologies in electricity generation, transmission and distribution technologies is becoming widespread [1]. The network system that is obtained by integrating computer and network technology to the electricity networks that operate almost the same way since Tesla is called Smart Network. Smart grids provide a real-time two-way exchange of information at every stage from the point of production to the point of consumption; Thus, more efficient and sustainable use of energy can be achieved. The main reason why such networks are intelligent is that the system can be monitored instantly with the help of the data from the sensors and the network is kept up to date by improving itself in the event of a possible downtime and the system is working stably [2].

Block chain is a global leader software platform for digital assets, a digital notebook designed to record financial transactions as well as the value of everything. Originally created for Bitcoin, the Blockchain technology is now slowly shifting to other sectors. Blockchain has many opportunities such as smart contracts and other transactions. The data can be executed without human interaction and the data is more resistant to modification as the data in a block cannot be changed backwards. Blockchain intelligent contracts are defined as technologies or applications that have the value acting as money and information arbitrators without a mediator. Blockchain database is distributed to the computer network, leaving no room for hackers. The system is completely transparent, all users can see the actions and changes made in public blockages. For this reason, many industry block chaining applications are working on their sectors. One of these industries is the energy industry. In particular, it is vital for smart grids to be safe against cyber attacks in smart grids, and the speed and shortness of monitoring a possible failure of the network. Blockchain will be used in the near future, especially for the modernization of smart grid systems. When you submit your paper print it in two-column format, including figures and tables . In addition, designate one author as the “corresponding author”. This is the author to whom proofs of the paper will be sent. Proofs are sent to the corresponding author only .

2. General Architecture of Blockchain Technology

2.1 What is Block chain?

In the Blockchain, blocks that connect to each other with a unique encryption technique come together to form data communities. Blockchain is a database technology. However, it is not enough to just define it as a database. Blockchain can be stored, and most importantly, to keep track of transaction; it is a system that encrypts and manages these data and processes, and no one is allowed to corrupt records by a block validation system. In addition, older processes are protected as long as the system continues, while newly created processes are protected by irreversibly adding to Blockchain. The data in the Blockchain structure is usually kept distributed. Blockchain can be defined as centralized or distributed according to needs, process or scope of application [3].

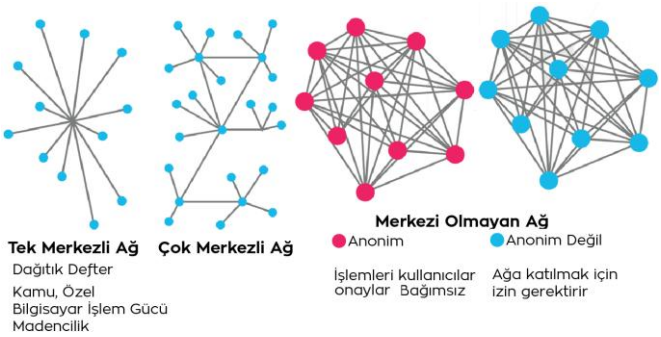

Figure 1: Network Structures Used in Blockchain

2.1.1 Central Database

The data in this database is held only on one server and is the management center. The central database has been used in the software world for many years. This type of database management is done by a certain group. Generally, the people involved in the management business are technical staff designated by the company. Security and maintenance of the servers are done by these people. Because a central server system is used, there is a problem in connection with all other applications. Such a situation is one of the biggest risks for the central database.

2.1.2 Distributed Database

Such databases do not store data on a single server, as is the central database. The data is stored on more than one server. The servers used in the distributed database differ according to the server models in the central database. For example, when you process Bitcoin, you will install all of your chain operations on Bitcoin Blockchain on your computer and now you will become a resource for the Blockchain on your computer. This will enable you to keep your data both without connecting to a central server and read data from within the Blockchain when different users want to obtain data. Since all data in the system is kept in more than one source, no vital situations such as data loss or deletion will occur. If the server in the system does not get the data from a source, it will be obtained by accessing another resource.

2.1.3 Encryption on Blockchain (Cryptology)

Because the data is distributed in the Blockchain system, the system automatically copies to each user in the chain. In this case, the data remains safe in the system and the data obtained is encrypted in the chain as jobs occur. After the encryption process, the data is kept in an encrypted manner in the system. In this type of encryption technique, both the transaction blocks and the processes are encrypted. The capacity of the blocks is determined by the number of transactions and the process size. In addition, each block has separate encryption even in itself.

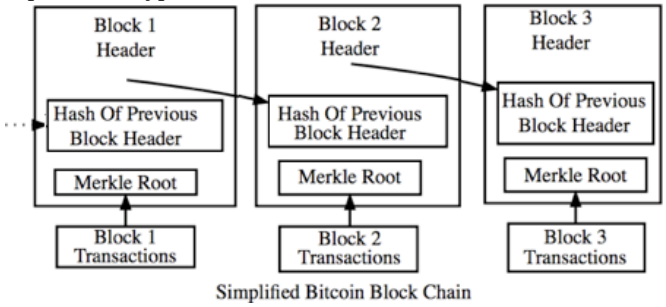

Figure 2: Blockchain Encryption System

Hash of the previous block header H and H Merkle Root ”is the most striking point in this phase. Each block in Blockchain uses its own special hash. Haslerin feature in no way can not be repeated. The hashs obtained in each block are derived from the previous block. This structure makes it impossible to hack the chain and keeps security at the highest level. Belir Merkle Root olup is the structure that manages the hash chains formed and determines whether the data are correct or not. Because each user can create data on the Blockchain, it must be checked whether the data is correct. Blocks and blocks generated by encrypted hashes cannot complete their operations unless they are approved by different resources in the chain system. Such a structure provides an excellent architecture for the protection of large data.

2.2 How Does Blockchain Work?

In order to learn the operation of complex systems like Blockchain, in-depth research is required. Blockchain is not a single operating system or program. Blockchain is a GNU (open source) system with different versions.

GNU; A number of applications that can work with a command line, timer, text editor, coder can be considered. It's important for hardware because Blockchain doesn't have a lot of hardware when it comes to delivering a great array of software. If you have a hardware problem, you can find the problem in the Blockchain solution list. Blockchain will be very useful to you if you are using it from your old computer or if your computer has low memory.

In the case of software, Blockchain has much to offer. Windows offers users a version for each application. For example; Text Editor Microsoft Word, Windows Movie Maker. Blockchain is a system that contains hundreds of applications, even thousands of applications. Blockchain will be offered many options even in a simple application. This proves that the Blockchain is a useful and readable system. Blockchain and Windows are very different systems. Even though they are different from each other, the logic of operation is the same.

2.3 What are the Features of Blockchain?

2.3.1 Data that Cannot Be Changed

The resulting chain can never be changed. So it is not possible to do a retrospective process. Because the authentication system is a distributed system.

2.3.2 Digital Trust

Confidence is a risk decision between different parties, and in the digital world, the determination of trust usually means proving identity (authentication) and proving authorizations. Blockchain technology private key encryption is a tool that meets the authentication requirements. It also frees a person from having to share more personal information, forcing them to share more personal information than is necessary for an exchange. Blockchain technology is often defined as the basis of the Value of Internet, the backbone of a value layer for the Internet.

2.3.3 Transparency

The Blockchain network is a structure that automatically checks itself every ten minutes. The network, a self-monitoring ecosystem of a digital value, reconciles every process that takes place in ten-minute intervals. Each group of these processes is called a ub block Bu. These blocks are transparent, and their data are built into the network as a whole and are open to the public. Disrupting any information unit in the block chain means using too much computational power to override the entire network [3].

2.3.4 Management

The system is fully transparent and open to the public. The choices are made with full transparency. Blockchain technology enables organizational decision making to take place in the block chain. In terms of management, the management of capital and information becomes completely transparent and verifiable [4].

2.3.5 Local Microgrids

Renewable energy purchase and sale transactions can be realized through local microspheres. For example, based on a Blockchain-based intelligent contract, the system automatically distributes energy when energy is generated by the solar panels. In real terms, smart contracts and Blockchain technology will be seen in many different areas [4].

2.4 Investigation of the Use of Blockchain in Smart Grids

Many industries are working on the applicability of Blockchain applications to their sectors. One of these industries is the energy industry. The current energy development process includes Blockchain. In recent years, especially in the energy sector Blockchain is thought to be a possible player. For this purpose, Blockchain is intended to help us to have a better and modern power grid. Because it is a great tool to modernize the power grid, it is possible to use the block chain to distribute or finance power supplies. The use of the block chain in power systems means that the Blockchain is trying to improve existing power networks by creating intelligent power networks. Technology improves our lives every day. Blockchain is a decentralized network that helps users secure information while allowing users to see data stored in a block chain. Therefore, Blockchain technology can be a great solution for electricity companies to build intelligent power networks.

Together with Dutch transmission operators Tennet, IBM, Vandebron and Sonnen, they announced that they will use Blockchain to develop a platform for managing electricity networks in the Netherlands and Germany in February. Vandebron will work with an electric vehicle fleet to provide grid storage services in the Netherlands. IBM will implement the Blockchain platform to process and verify data throughout the project. Other network operators are taking similar steps. For example, National Grid works with Google's DeepMind to discover that its algorithms can help balance supply and demand. This can lead to the use of similar technologies within distribution networks or even among households [5].

2.4.1 How Blockchain Can Prevent Faults in Smart Grids?

The process of monitoring a fault in power networks will be better with the Blockchain. One of the reasons Blockchain appears to be a promising application is that power grids can quickly transfer companies' status so that companies can detect problems faster. With the use of modern technology and the intelligent Blockchain network, power grids can advise the authorities about which tools and devices are needed to bring the electricity grid back to normal operation. It is clear that the use of block chains in smart grids will be a successful process; because the block chain can reduce the losses of companies when there is a running fault. The block can store information about everything related to power networks, including past issues, as well as being able to inform authorities about current or potential failures. Storing this information will improve transparency, as well as to see if users need some changes, renewals, or new installations.

Blockchain technology allows customers to inform the company about some power outages. This will improve power networks and reduce company losses and errors.

2.4.2 Potential Benefits of Blockchain for Smart Grids

The benefits of Blockchain for smart grids are:

a) Increases reliability and preserves the integrity of the data.
b) Supports multi-factor verification through a distributed notebook.
c) Ensures the integrity of the process data.
d) Reduces energy exchange costs by removing agents.
e) Facilitates the adoption and cash conversion of DER (Distributed Energy Resources) transactions: All transactions are carried out in real time and carried out on the basis of actual consumption.
f) It can provide additional storage and auxiliary transformer balancing from energy systems by enabling consumers to be producers.
g) Rapid detection of data anomalies can increase the ability to detect and respond to cyber attacks.
h) Potentially helps to reduce transaction costs in the energy sector.

2.4.3 Smart Contract Application for the Energy Sector

Smart contracts facilitate the exchange of peer-to-peer energy by enabling energy consumers and supplies to be sold to each other, rather than on a multilayered system where power and transmission systems operators, energy producers and suppliers operate at various levels. In April 2016, an application has been developed in which decentrally generated energy is sold directly between its neighbors through a block chain system in New York, where energy producers and energy consumers can carry out energy supply contracts without the participation of a third party. In addition to potential cost savings, transaction data has become more secure with decentralized storage and multi-factor validation in the distributed notebook. At the deployment level, system operators can use Blockchain to receive energy transaction data to bill the network costs to consumers. Operations can be performed and analyzed on the basis of actual consumption, reducing data requirements and increasing the speed of swap transactions for transmission

system operators [6]. Smart contracts, Blockchain executes and saves the transaction in the Blockchain load book, especially through the advanced metering engine. Blockchain-based smart contracts have partially secured data through all energy flows and decentralized business operations. This underscores the indispensable potential for the block chain in the energy markets by the introduction of a more autonomous and decentralized transaction model. This peer-to-peer system can reduce or even change the need for a counter operator if the counter block chain is shared with the distribution system operator.

2.4.4. Providing Virtual Security of the Network With the Help of Blokchain

Blockchain provides a unique way to provide virtual security. These methods include distributed blocks that cannot be modified retrospectively. This helps increase reliability and maintain data integrity. At present, there are two main problems that threaten the safety of the electrical infrastructure of smart grids. First; authentication and encryption reliability, second; high cost of switching. Blockchain applications can actually overcome these basic two problems. With an advanced encryption method, it can protect the communication between the lines against the cyber attacks that are likely to occur by conducting authentication and encryption. This approach is crucial to ensure the security of various cloud-based energy management solutions for buildings and facilities, and for the use of existing energy infrastructure and cloud platforms. Combining cryptographic signing events and distributed infrastructure can help to increase data, competitiveness and real-time energy exchange for micro-networks, and increase the suitability of buildings for energy production and sales.
Increased data accuracy provided by Blockchain can also help in identifying targeted cyber attacks and increasing the flexibility of distributed energy resources into the network. Current techniques currently used in energy distribution and connections from buildings to networks are vulnerable to cyber attacks.

Integration of distributed energy sources without proper cyber security measures, including reliable communication and monitoring, potentially destabilizes the power grid and creates interruptions and reliability issues for customers. At this time, attackers attempt cyber attacks to compromise the input-output signals of the control algorithm of distributed energy sources. Blockchain can help reduce such attacks because your notebook saves energy processing time and uses the data stored in the block. This provides a method for verifying which data is valid and what data is invalid. This method allows the Blockchain platform to quarantine data, drop out malicious commands that are not in the smart contract, and return to a fixed state. The effect of the attack depends on the number of devices seized, the location of the devices (eg, near the substation or away from the substation), the condition, configuration and characteristics of the dispenser, as well as the type of attack. Of course, there is a need for additional research and development of block chain security applications to safely identify distributed energy sources and perform rapid operations.

In addition, policies and standards are required to facilitate the placement of the block chain in the power grid. Lockchain-based intelligent contracts improve both network modernization and security technology by increasing the reliability and efficiency of electrical infrastructure. Blockchain is based on a proven cryptographic signature that interferes with the manipulation of energy processes and configurations of energy distribution systems. Due to its distributed structure, instant record and encryption signatures, Blockchain is more resistant to cyber attacks than centralized systems in the power grid. Smart contracts also enable real-time energy applications that work with the reliability, security, and controllability of data, eliminating the need for third parties to validate and implement contracts. Blockchain increases security through authentication, encryption, and the ability to verify the integrity of data.

3. The Blockchain Applied To The Smart Grid

3.1 Metering Case Study

The metering case study is based on an enhanced level of adoption of the Blockchain and offers simple functionalities withrespect to the electrical power system. By addition of computational capacity to the Blockchain a decentralized computing platform has been created. The metering case study involves using these computational capabilities combined with the smart metering infrastructure installed throughout the electrical power system to ensure a higher level of security and integrity.Therefore, the metering case study should be considered as the first practical application of the Blockchainwithin the electrical power system.

In Figure 3 an overview of application of the metering case study has been shown. In the metering case study the entire electrical energy market is operated via the Blockchain. Parties involved with the electrical energy market and smart metering devices within the electrical power system exchange information with the decentralized computing platform in order to establish maximum security by eliminating the energy double spending problem.

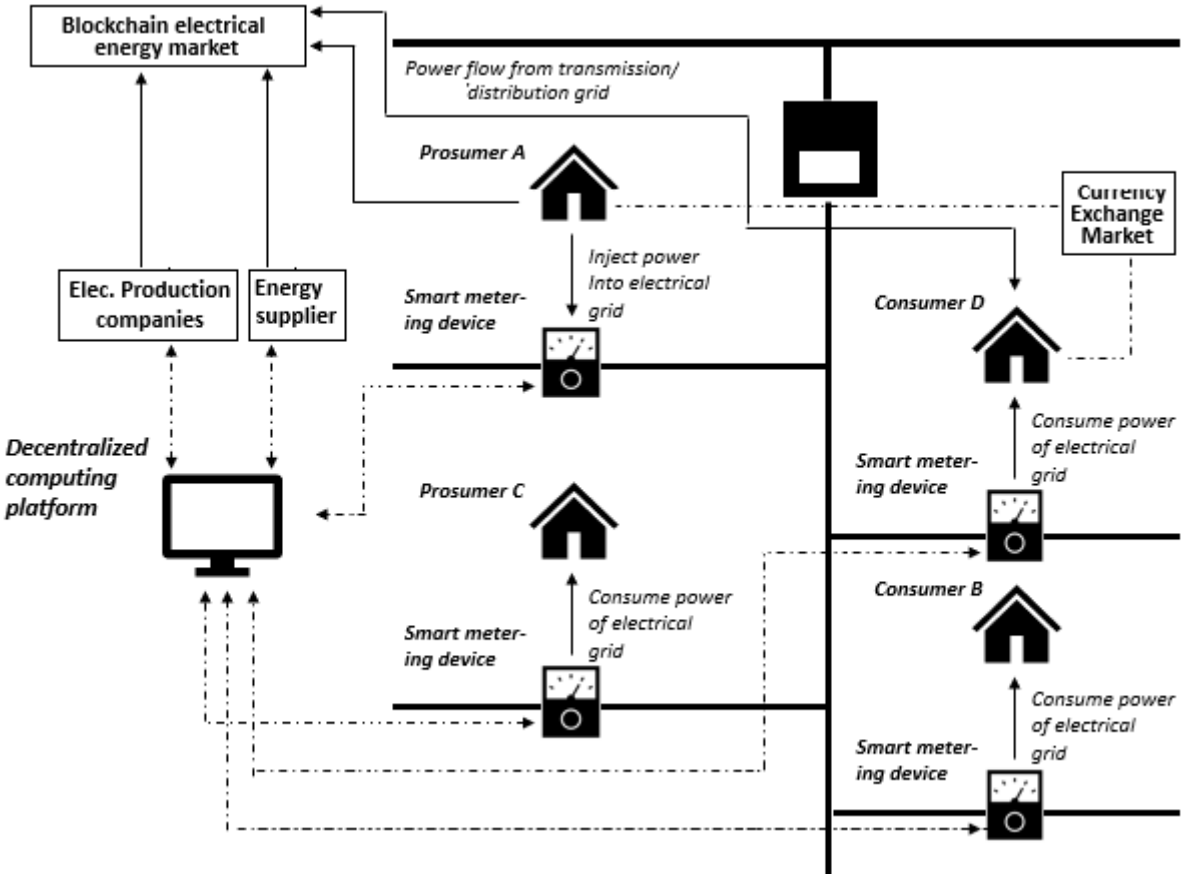

Figure 3: Overview of application of the metering case study in electrical power system

As shown in the Figure 3; prosumer A sells electrical energy to consumer D via the wholesale market which operates via the Blockchain. Consumers and prosumers have the ability to buy and sell electrical energy via the electrical energy market. In essence there would be no necessity for the role of the energy supplier however it would be unlikely that consumers want to bear the responsibility of maintaining the balancce between load and generation. Therefore, in the application of the metering case study the energy supplier is still present.

3.2 Control Case Study

Similar to the metering case study, the control case is based on an enhanced level of adoption of the Blokchain. Computational capacity is added to the trading infrastructure of the Blockchain in order to create a decentralized computing platform. The control case study involves the application of the decentralized computing platform combined with smart metering infrastructure in order to offer highly sophisticated functions with respect to the electrical power system.

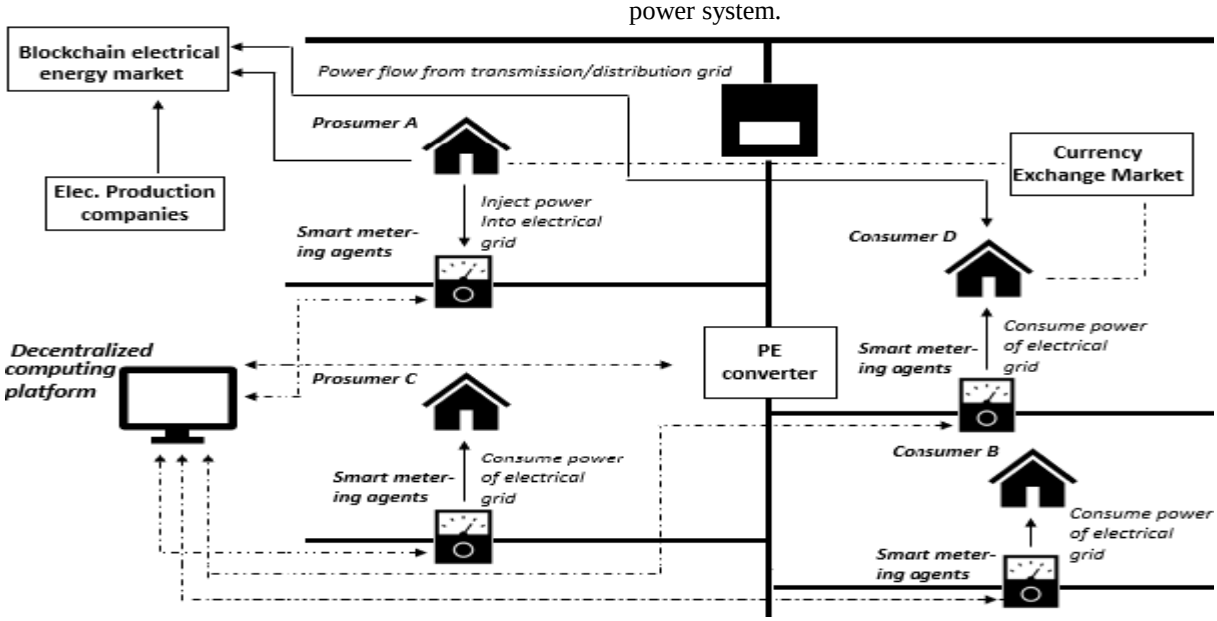

Figure 4: Overview of the application of the control case study within the electrical power system

The control case study offers advanced functionalities such as inclusion of transmission and distribution cost and more accurate demand side forecasting. However, in addition to the control case study offers highly sophisticated features such as dynamic load shedding and primarily the ability to control power flows within the electrical power system.

In Figure 4, an overview of the application of the control case study has been presented. Similar in setup to the metering case study where prosumers and consumers buy and sell electrical energy via smart metering devices which act as automated agents. The decentralized computing platform is coupled to the smart metering agents combined with power electronic converters installed throughout the electrical power system in order to perform dynamic load shedding and to control the power flows within the electrical power system.

4. Results

It is early for Blockchain applications for the energy sector and especially for smart grids. Especially Blockchain technology has the potential to shape the energy resources we will use in the future. With the advancement of this technology, the modernization process of smart grids will be accelerated, the system will further reduce the time of self-recovery in the event of a malfunction, and will be particularly resistant to intelligent grid virtual attacks. Readers of remote meters will be Blockchain technologies where energy is used to generate a value such as electricity trade, electric cars, distribution of network services, wholesale electricity sales, or where energy services and resources are used.

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