Review on Architecture of Blockchain Enabled Decentralized System

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***Abstract*— With the expansion in the Internet infrastructure demands of internet technology increased and there is a need of a secure system that is decentralized in nature, combined with secure and transparent infrastructure which is fulfilled by one of the trending technology named as Blockchain.**

Blockchain technology has expanded significantly over the past few years, with new applications and use cases being discovered and developed every day. The decentralized nature of blockchain, combined with its secure and transparent infrastructure, has made it a highly sought after solution for various industries, including finance, healthcare, supply chain management, and government services. The expansion of blockchain technology is a result of its increasing adoption and integration into various sectors such as finance, healthcare, supply chain management, and more. One of the key drivers of the expansion of blockchain is the increasing demand for secure, tamper-proof and transparent transactions. This has led to the development of various blockchain platforms, such as Ethereum, which helps in the development of decentralized applications or dApps for the variety of purposes from financial records to data storage.

***Keywords*— *dApps, nodes, tamper-proof, transactions, P2P, contracts, censorship*.**

I. INTRODUCTION (*HEADING 1*)

As the digital era emerges, Blockchain technology have also gained popularity in recent years as a way to create secure, transaparent and decentralized systems. Blockchain is basically a distributed database or ledger of records by distributed we can say that the copy of records are not in centralized database instead of centralized database the copy of database is also available to all the nodes (i.e devices connected on the network) in such that the no changes are no possible in the records i.e it is immutable in nature.

Blockchain is basically become popular by the advancement of Bitcoin which is a open source online currency and that is immutable in nature. Everyone hears the word Bitcoin instead of Blockchain it is like that when we come to toothpaste we can call it is Colgate instead of Toothpaste. The other popular blockchain based E-Currencies are Bitcoin, Dogecoin etc. There are many Blockchain network available in the world in which some popular ones are Ethereum.

In the context, the discussion will provide an overview of the architecture for Blockchain technology, involving its key components that works together to supports the development of decentralized system with its advantages and disadvantages along with that there is also discussion of blockchain and smart contracts along with that we also learn how we can integrate blockchain into our web based application. We will explore the network, the consensus , the data structure and smart contracts components and challenges in that.

II. WHAT IS DECENTALIZED SYSTEM?

A Decentralized System is basically a system of nodes or devices in which the data or ledger is not stored at a centralized server instead of that data is shared over each nodes. Each nodes acts as a separated system with all records [See Figure 1]. As the data is stored across all nodes (i.e Devices on Network) then it is not possible to temper any record as for tempering we need to update data at each node which is not possible.
It refers to transfer of control and decision making from a central authority to a decentralized authority.

Figure 1: Decentralized Architecture

A. Centralized System Vs Decentralized System

The major differences between the Centralized System and Decentralized Systems are:

Centralized System	Decentralized System
Maintained and controlled by a single entity hence easy to temper	Does not maintained or owned by a single entity hence difficult to temper.
Maintained and controlled through central system	Data is added after consent from all nodes

Control through central entity	No one owns that data and everyone own the data
Maintained and controlled through central system	Increases when no of nodes increase
Maintained and controlled through central system	Decreases when no of networks increase.
Ex.: ERP System	Ex.: Blockchain

B. Merits & Demerits of Decentralized System

Merits of Decentralized System:

- It provides a trust less environment as each one have the copy of database.
- Improves data reconciliation
- It reduces points of weakness
- It increases or optimizes distribution.
- Immutability
- Security
- Transparency and Full Control by Nodes.

Demerits of Decentralized System:

- Cost
- Lack of Consensus and Clarity
- Lack of Discipline

III. BLOCKCHAIN

A. What is Blockchain?

Blockchain is basically a distributed immutable ledger where data is stored in the form of blocks for each new information or data a new block is created and has also store the hash of the previous block in such a way that it creates the chain of records. Hence Blockchain is the composition of various Blocks which are linked together where each blocks consist some data and some raw data like timestamp, previous hash etc.

In case when anyone changes the data in the ledger then that data is matched with the data stored in the different network along blockchain network and if the majority is in the favour that data is tempered then the changes data is replaced with the original data.

The Structure of Blockchain Block is here depict in the Figure 2.

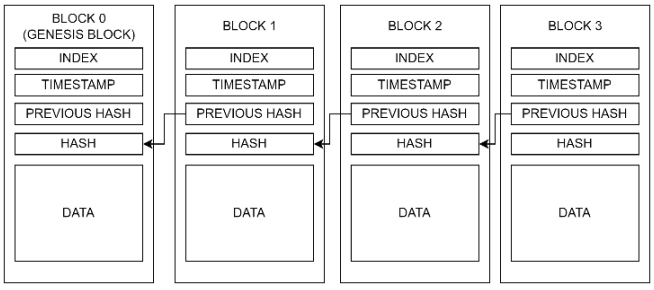

Figure 2: Structure of Blocks in Blockchain Network

B. Structure of Blockchain

The Structure of Blockchain consists of the Blocks which are chained together in the regular fashion each block in the network stores the address of previous block. The First Block in the Blockchain network is called as "Genesis Block" or "Block 0" as Blockchain chain originates from here.

The complete information regarding structure of Blockchain is also depict in Figure 3.

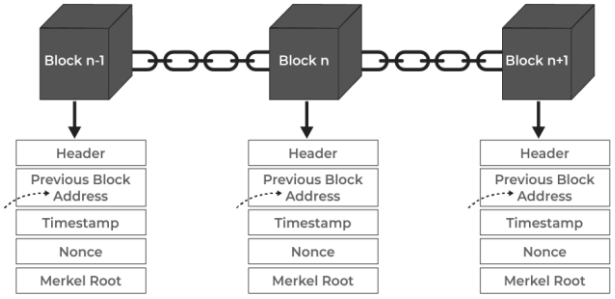

Figure 3: Structure of Blockchain

C. Requirements of Blockchain

As the world moves towards the digital era due to that needs of the database increases and the regular database is easy to modify becomes all the records are stored in the centralized storage which are in same or different geographical area.

Due to data tempering everyone needs a trusted database which is impossible to temper and have no centralized storage so we moves towards the decentralized storage where data is not stored in central server instead of that data is stored on each node means a copy of data is available to each node which means in case of any change the data is matched with the data available to other nodes which is close to impossible so blockchain prevents tempering of the data.

The main requirements of blockchain are:

- To develop a trusted data which is impossible to temper.
- To stores records like Educational, E Documents blockchain based storage is needed.

D. Merits and Demerits of Blockchain

Merits of Blockchain:

- Immutability: Blockchain supports concepts of Immutability which means the records are impossible to temper i.e Blockchain prevents tempering of data within blockchain network.
- Transparency: Blockchain is transparent in nature as te copy of records is available to all nodes available in the network.

Demerits of Blockchain:

- Speed and Performance: Blockchain is considerably slower than that of traditional database as while working with records blockchain more operations are carried out which decreases speed on insertion of records.

  Speed and Performance is also proportional to no of nodes in the network
- Costly: As blockchain is costlier as compared with the traditional database as it requires proper planning and integration with blockchain.

- Data Modification: It is not easy to insert or update records in the blockchain for that we need to write codes or contracts which is time consuming and expensive.

IV. Smart Contracts

Smart Contracts are basically the programs stored in blockchain that automate the task of execution on agreement with predefined conditions which is set up when developing smart contracts. In the other way we can say that smart contracts are basically the authentication system of the blockchain which have predefined conditions which is first checked when new block is inserted in smart contracts.

Smart Contracts are written through a programming language called "Solidity" which is a object oriented language and licenced under GNU General Public License v3.0. Smart contracts also help in automate the task of workflow, triggering the next action when specific conditions met

Here below is the simple Smart Contract for Todo List written in solidity:

```
pragma solidity >=0.7.0 <0.9.0;

contract Todos {
    struct Todo {
        string task;
        string timestamp;
        bool status;
    }
    mapping (address => Todo[]) private Users;

    function addTodo(string calldata _task,string
calldata _timestamp) external{
      Users[msg.sender].push(Todo({
          task:task,
          timestamp:timestamp,
          status:false
      }));
    }
```

V. Blockchain Enabled Decentralized Systems

Blockchain is the way to store records in the form of distributed ledger which develops the concept of Decentralized System. Traditionally, Centralized System was used which have certain disadvantages and certain limitations (i.e No Data Immutability, Single Point of Failure and Less tolerance), where there is a task of a central authority to control and manages the system. However in Blockchain Enabled System or Decentralized System there is no central system which means there is no single authority who manages and maintain the system and have no central point of control or data.

In Blockchain powered Decentralized System records are not stored on a central server instead of that records are stored on each nodes. In Blockchain transactions are validated and recorded on a distributed ledger which is composed of multiple devices which are connected on the network called as Nodes. Each node have the copy of the complete ledger and validated by consensus among all the nodes.

The Decentralized approach comprises of Blockchain have multiple benefits such as it eliminates central authority or intermediaries such as Banks and other financial institutions which reduces running cost as well as increases efficiency other than that these type of system increases transparency and security as the records are immutable and tamper-proof and can be audited by any node in the network. The Decentralized System powered by Blockchain have the potential to transform traditional industries into modern Industries by creating new Business Model.

For Example: Let's take the example of Decentralized Finance (DeFi) a new Innovation in the field of Blockchain which creates emerging path for Blockchain to take control over financial transactions. DeFi now emerged as the new paradigm in the finance industry, offering a range of financial services involving E-Currency, Crypto-Currency etc. that are accessible to everyone regardless of Internet Connection, geographical location and financial status. Other than financial services, Blockchain also involved in Supply Chain Management, E Voting and Digital Identity Verification.

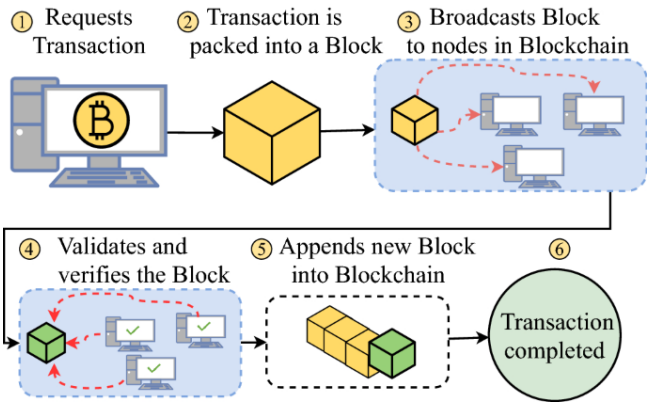

Figure 4: Process of Block Addition in Existing Blockchain

A. *Role of Blockchain*

In Decentralized System Blockchain helps in creating records which are not on central server instead of that they are the nodes (i.e Devices connected on Blockchain Network) which means they are not handled by central authority and Blockchain provides smart contracts which are generally the Programs that matches the predefined conditions and on the basic of that condition the particular action is triggered.
Every new record or block on the blockchain proven to be authentic and digitally signed to ensure its genuine. Before its addition to blockchain, it should be verified by the majority of nodes among network.
In Blockchain the new Records can go through various phases involving validation. These are:

- A Transaction is requested
- A Block that represents the transaction is created.
- The Block is sent to every node in the network
- Nodes validate the transaction
- Node receive a reward for the proof of work
- The Block is added to the existing Blockchain
- The Transaction is complete.

B. *Types of Blockchain Architecture*

Blockchain architecture may be implement in three ways:

- Public Blockchain Architecture
  In the architecture, the data is available to public who is willingly to participate ex. Bitcoin, Ethereum are follows public blockchain architecture.
- Private Blockchain Architecture

In this architecture, the data to only available to the members of the organization or any other person who are invited to the organization as guest.

- Consortium Blockchain Architecture

In this architecture, the data is available to public as well as for the users of an organization. This architecture also used when there are multiple organization where that can share their data.

C. Types of Decentralized Architecture

The Blockchain basically follows one of the following levels of decentralization:

- Fully Centralized
  These blockchain system are entirely controlled and managed by the single central, authority
- Semi – Decentralized
  These blockchain system are managed and controlled by multiple authority.
- Fully Decentralized
  Have no central authority for the management.

D. Requirements of System

The main reasons for the requirements of the Blockchain Enables Decentralized System are:

- Immutability: Everyone wants Immutable data which means that data is authentic and did not change by anyone thus Blockchain Enables Decentralized System is the solutions for that. It prevents data tampering as all blocks are connected in a chain and in case of tampering chains is disturbed and other one is that each node on blockchain network have the copy of the data and in case of tampering the data is recovered to the authentic data through the concept on consensus protocol of blockchain.
- Transparency: Blockchain increases transparency in the data as data is available to all the nodes in the network which means anyone within the network can view the data as per their access. So Blockchain enables Decentralized system are also required to increase transparency in the data.
- Single Point of Failure: Blockchain enables Decentralized System also reduces the single point of failure as the data is not accessed through a single point or central server.
- Fault Tolerance: Blockchain enables Decentralized System is very fault tolerance as there is no dependent on the central server and there is no load on the central server instead of that loads are split into the nodes or devices connected on the network.

E. Pros. and Cons. of System

Pros of Blockchain Enables Decentralized System:

- These System proofs the authenticity of the data which means that the Data stored in these are authentic in nature and are tampered proof.
- These systems have no Single Point of failure due to the absence of the central server.
- These System have maximum Fault Tolerance as each node on the network have own hardware and there is no dependence on the infrastructure of central system
- The data in this system are transparent in the nature as data is available to every node on the network.

Cons of Blockchain Enables Decentralized System:

- These System have limited Speed and Performance which means speed and performance are inversely proportional to no of nodes on the network as when no of nodes increase the speed and performance decreases and vice versa.
- These cost of setup of these system is high as compared to central system.
- Each operation in this system takes time to execute as it has gone through various smart contracts.
- Blockchain have limited scope as further research is going on it.

VI. Architecture For Blockchain Enables Decentralized System

The architecture of the blockchain technology comprises of distributed network of nodes (i.e network created by connecting multiple devices or nodes together) that work together to validate and record transaction on the blockchain ledger along with these devices there are there are some programs needed for validation of conditions known as smart contracts. This architecture enables decentralized systems to be build, as no single entity or node have no access to whole network.

As per the core fundamentals, blockchain architecture consists of the three main components:

- the network
- the consensus mechanism or protocol and
- the data structure needed to store the blocks which comprises of records.

A. The Network:

The network components or the setup generated by connecting multiple devices or nodes to form the decentralized network. These nodes can work together to ensure that the blockchain remains secure, transparent and tamper-proof.

B. The Consensus Protocol:

The Consensus protocol or mechanism ensures that all the nodes on the network have the current state of the blockchain which is achieved by various algorithms comes under consensus protocol such as Proof of Work (PoW), Proof of stake (PoS) and Delegated Proof of stake (DPoS).

C. The Data Structure:

The data structure of the blockchain deals with the storage of the transactions records of the transaction that took place on the network. Each Block of the Blockchain consists information about the set of transactions, along with unique cryptographic hash that contains the reference to the previous block which leads to the chain of blocks In the other way we can say that Blockchain starts with “Block 0” or “Genesis Block” upto “Block N” where each block stores the reference to the previous block which means each n block consists of the reference to n-1 block that creates the chains of records.

In addition of these core components i.e the network, the consensus protocol and data structure. Blockchain architecture also includes smart contracts (the self-executing contracts the type of agreement between parties written in the form of code using Solidity Programming Language). Smart Contracts allows the automation of complex transactions and can be programmed to execute trigger based on a specific condition.

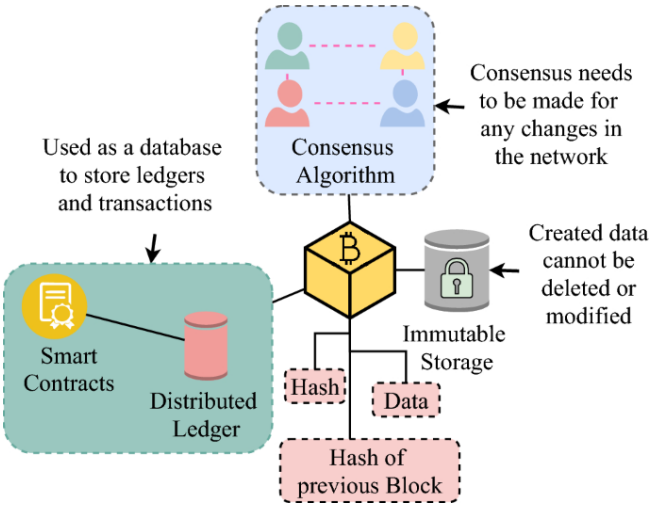

Figure 5: Core Components of Blockchain

Overall, the architecture of blockchain development of transparent, tamper proof decentralized system. By leveraging a distributed network of nodes, consensus mechanism and a tamper proof data structure with the potential to create innovations.

For the development of decentralized systems using Blockchain we must go to the mentioned steps:

1. Choose the Blockchain Platform: The First step in the development is to choose a blockchain platform from available blockchain platforms i.e Ethereum, Hyperledger, and EOS etc. among those available choose that platform which suits system requirement.
2. Develop Smart Contracts: The next step is to develop smart contracts using solidity here we have to develop smart contract that governs our app functionality.
3. Create Decentralized Application (DApp): Develop the app that can work with smart contracts and allow users to execute system functionality.
4. Define User Roles: here we have define the access based user roles.
5. Integrate with a cryptocurrency: To make system functionalities work properly we need to connect our app with the cryptocurrency such as Ether or Bitcoin.
6. Publish the DApp: To make System accessible to everyone we need to published app on the chosen platform.
7. Data Audit: As Blockchain is highly secure but we must take regular audit of the data and use encryption and other privacy enhancing technologies to protect user data.

VII. Blockchain Enables Decentralized System Development And Challenges

As discussed above in this chapter Blockchain enabled Decentralized System have the capability to develop a system that provides a way to record and verify transactions securely and transparently. Decentralized Mode is achieved by connected the multiple machines on a network which helps in validation and recording of transactions.

On of the major advantages of Decentralized System based on Blockchain technology is that they are free from censorship and control of single authority or government as nodes ensures that no single node have the complete access over the blockchain network. Decentralized system also provides the way to store data in a tamper proof environment and that can be accessed through necessary permissions.

However, there are various challenges in this Blockchain based Decentralized journey. One of the popular is Scalability as the current blockchain can only handle limited number of transactions within seconds that makes blockchain decentralized system to take control over centralized system which can handle millions of transactions within seconds.

Another one challenge associated with Blockchain based Decentralized System is that Lack of Interoperability which means adoption and integration of that in various industries and platforms. Along with that there is also the challenge of Government Regulatory as developing of regulatory also makes adoption slow.

Overall, while blockchain technology helps in the development of decentralized system which have its own various advantages, there are still several challenges that need to be addressed in order to fully realize the potential of these technology, Further research is going on Blockchain which helps in creating backdoor in the adoption of Blockchain technology in various fields including E-Voting, Supply Chain Management, Academic Records Management etc.

VIII. Future Of Blockchain Enables Decentralised System

The Future of Blockchain technology and with its ability to develop decentralized system is promising. As these continue to maturity by providing better solutions to some of the sectors where it can make significant impact. One area where Blockchain Technology can make the significant impact which is the Financial Sector which is one of the crucial sectors involving records with money transactions entry which must be temper proof. Decentralized Finance (DeFi) applications which are built on the blockchain technology have already emerged, enable P2P lending, trading without the need of a central authority or financial institutions. Another area where Blockchain makes the huge impact is “Supply Chain Management” involving management of the records related to the supply of goods. Its increases transparency, reduces fraud and improves efficiency of the supply.

Others area where Blockchain creates the huge impact are Online Voting, Academic Records Management etc. Blockchain technology also be used to develop decentralized identity system that enables individuals to take control over personal data and protect their privacy online more

information about future use of blockchain technology are depict in Figure 6.

The future of Blockchain includes integration of it with IoT, Artificial Intelligence and Machine Learning to keep records temper proof. These technologies can leverage the decentralized and secure nature of blockchain to develop innovative solutions to various industries.

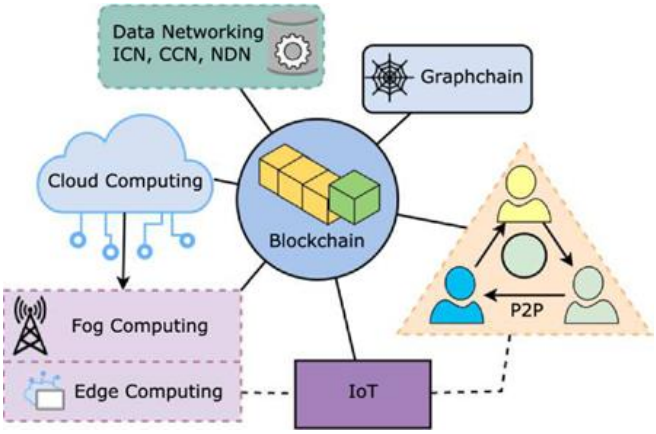

Figure 6: Future of Blockchain Enabled Decentralized System

CONCLUSION

In conclusion, we can say that the blockchain technology have the potential to change the way we build decentralized system, by providing transparent and tamper proof management of records and prevents the censorship of records as well as management by a signal central authority or Government. Decentralized System powered by Blockchain have the potential to transform industries involving finance, education, voting, supply chain management and identity management by developing transparency and reduce fraud that leads to the trust that records are authentic and leads us to the Web 3.0.

These have also some challenges as discussed above which is possibly be reduced in the near future as research is going on the blockchain.

Overall, the potential benefits linked with Blockchain technology and decentralized system are significant and it is an exciting time for the developers to leaps into it by exploring further opportunity in that and develops world changing innovation's.

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