A Conceptual Study on Holochain and Blockchain Technology

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In this paper, we study and describe the conceptual differences of a new and upcoming technology called Holochain Technology along with that of widely used, Blockchain Technology. The working and architecture of both of these technologies have been studied purely at the conceptual level in order to ascertain the differences among them and decide the more efficient technology of the two. Our focus during the study was on the creation of chain, validation of the data uploaded on the chain and its integrity. Moreover, one of the important factors that we considered during the study was the effect of increased number of transactions in the current chain due to the addition of more nodes. Hence, in this paper, scalability is considered as one of the major factors that plays part in the performance of these two technologies. Thus, at the end of the paper, we will find out which of the two technologies studied here, will be used with more prevalence in the future.

Keywords: Agent-centric, Blockchain, Data-centric, Distributed storage, DNA, hApp, Holochain, Mining, Transactions, Validating DHT.

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1 Introduction

Blockchain is one of the most important technologies behind the working as well as development of various crypto currencies available in the world today. In fact, it is because of Blockchain Technology that we are able to visualize and use these crypto currencies currently. It is also such a technology that it will have a significant impact on myriad of functions like national governance, institutional operations, educations and our daily lives in 21st century [1].

One of the primary implementations of Blockchain was introduced by Nakamoto in 2008, in his work of developing the first ever crypto currency in the world called bitcoin [2]. Due to the features like trustworthiness, transparency and high immutability in the process of executing transactions in the network using blockchain, it has many applications in different domains existing today [3]. We can describe blockchain technology as a decentralized transaction and data management method which allows community users to validate, keep and synchronize the content of the transaction ledger which is replicated across multiple users [2, 4].

Now, there is one more new technology which is upcoming and may give competition or prove to be better than Blockchain Technology, this is Holochain Technology, which we will be describing along with Blockchain throughout this paper.

As mentioned in [2], Blockchain has the problem about figuring out how to choose one block of transactions among the many variants being experienced by the mining nodes and committing that single variant to the single globally shared chain. We call this approach data-centric because of its focus on creating a single shared data reality among all nodes. This data-centric approach results in one of the major limitations of blockchain which is scalability and there are many solutions offered to overcome this limitation [5].

Holochain is one of the best solutions to this problem faced by Blockchain as it is a scalable, peer-to-peer, agent-centric distributed computing platform with data integrity [5]. Holochain offers a way forward by directly addressing the root data-centric assumptions of the blockchain approach as it works purely on agent-centric approach. A real-world analogy for such an approach is git [6]. In git, shared state of chain entries (known as commit objects) across all nodes is not managed by itself but rather explicitly by action of the agent making pull requests and doing merges. We call this approach agent-centric because of its focus on allowing nodes to share independently evolving data realities [5]. This is the same way how Holochain works using its agent-centric approach and results in a much more efficient technology compared to blockchain.

2 Principal Concepts for Working of Blockchain & Holochain Technology

2.1 Concepts for Working of Blockchain Technology

As mentioned in [7], one of the main concepts on which Blockchain Technology works is decentralized database where there are individual copies of databases across multiple computers and all these copies are identical. Thus, we can now say that Blockchain works with a data-centric approach as described before but all this data is decentralized in databases across different systems. Apart from decentralized database, some other concepts which are a part of working of Blockchain Technology are asymmetric key cryptography, transaction, consensus algorithms and hashing [8]. Moreover, whole Blockchain

uses Peer-to-peer networking for processing transactions [7]. We will now see all these concepts in some detail.

(i) Asymmetric Key Cryptography:

The blockchain network secures the operation of the blockchain using public-key cryptography. All the transactions executed by the participants, except those on their native platform, would not be performed without a digital wallet. A digital wallet is secured with private key of the participant which can only be accessed using the signature that is generated by the corresponding public key.

(ii) Transaction:

Transaction in a blockchain network could be defined as a small unit of task stored in public records. The transactions which are steadily generated by the nodes and congregated in blocks represent the current state of the blockchain [9].

(iii) Consensus Algorithms:

At the beginning of the data propagation by blocks in the Blockchain, there is no centralized parties which regulates and resolve disputes in the network as well as protect it from the intrusions. Now, in order to maintain consistency and prevent fraud in the network, blocks should not be simply added and made part of the blockchain without any consent. There should be a common updating protocol to which all the nodes should agree and whenever a block is added, consent to this protocol must be given by every node. Thus, this consent-based mechanism which is followed by all the nodes to create blocks and add to the blockchain is called consensus mechanism [8].

(iv) Hashing:

A hash function is used to map the original data (message) to a collection of data of fixed size (i.e., hash value). Every block in Blockchain contains the hash value of the previous block in order to preserve the integrity and prevent the alteration of the transaction records [10].

The above given concepts form the architecture of the Blockchain which is divided into three layers as shown in figure 1. At the top layer of the architecture there are all the applications which are working with their respective digital wallets containing public and private key. Then, there is the decentralized ledger which is the database copy consisting of all the data related to participants, tokens issued by them and transactions initiated and terminated in the network. In this middle layer, there are blocks which are created by the grouping of individual transactions of participants which are added to the end of current blockchain after giving consent as per the consensus mechanism. This grouping of all individual transactions into specific blocks is called mining. In order to determine the legitimacy and cumulative effort required to build the chain, the decentralized ledger of Blockchain uses a proof-of-work algorithm which also assures consensus to the participants across all the nodes. At the bottom most layer or at the core of Blockchain Architecture, there are nodes playing various roles and exchanging different messages with the decentralized ledger using the Peer-to-peer network.

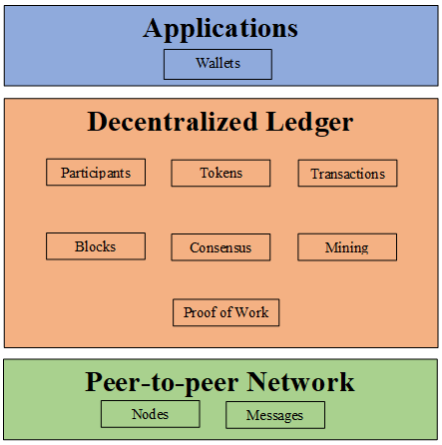

Fig. 1. Architecture of Blockchain Technology

Based on the architecture shown in figure 1, how a Blockchain Network works does is shown above in figure 2.

2.2 Concepts for Working of Holochain Technology

Some of the most fundamental concepts behind the Holochain Technology are zomes, DNA, Client, Holochain App Bundle, and Conductor [11]. The details about all these terms are described below:

(i) Zomes:

All the modules of the applications which define its core logic are called zomes. You can also create a zome and publish it as an API.

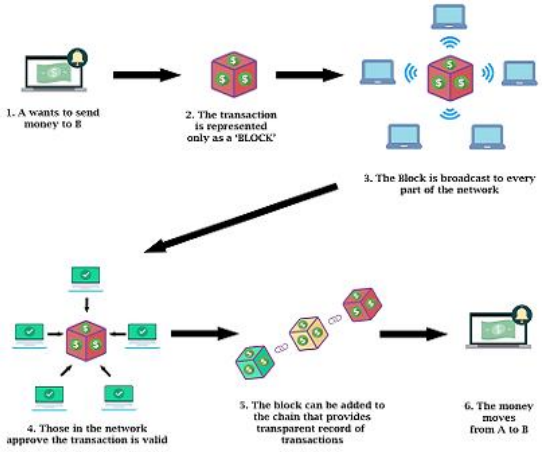

Fig. 2. Working of Blockchain Technology

(ii) DNA:

Combination of one or more zomes which serves the primary functionality for a specific part of an application is called DNA. It can also be considered as a micro-service which is running for a particular required task. There can be more than one DNA instances inside a single holochain application which are communicating with each other's API using bridging as shown in figure 3.

(iii) Client:

A GUI, Script or any piece of code which rests on the users' device and talks to the DNA's API via a lightweight Remote Procedure Call is called a client. It is like the front-end of a traditional application.

(iv) Holochain App Bundle:

Combination of clients and DNAs make up a Holochain App Bundle (hApp).

(v) Conductor:

A runtime that sandboxes and executes DNA code, manages data flow and storage, and handles connections between components of the stack is called a Conductor.

In figure 3, we can see that how are zomes, DNA, hApp, Client and Conductor are interacting with each other to provide a solid architecture for the Holochain Technology. Figure 3 also shows that the architecture of Holochain is divided into three layers namely: Client, hApp bundle and Conductor.

Moreover, it is completely evident that Conductor Layer which is the bottom-most layer also contains hApp bundle which constitutes of Client Layer too. Thus, DNA and zomes are the entities which are the backbone of the architecture as they are integral part of both the hApp bundle and they are the logic on which the Client Layer runs. From the architecture, we can also think Conductor as an application server which hosts, the back-end on which the GUIs and scripts of Client Layer runs.

The architecture provides us the concepts on which the working of the Holochain Technology depends. Through the concepts of this architecture, we can divide the working of the Holochain Technology into three primary subsystems as follows [12].

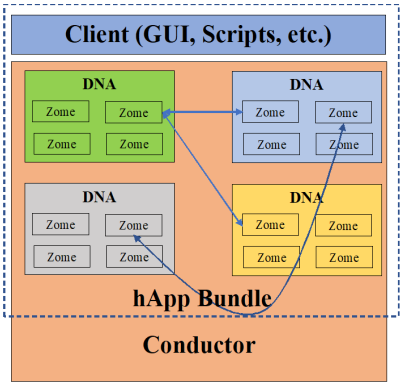

Fig. 3. Holochain Technology Architecture

(i) Application (Nucleus):

It is connected to the browser through an UI and helps in unifying the overall Holochain Ecosystem. The main task of it is to read and write on the local source hash chain while inputting or extracting data via Distributed Hash Table (DHT) which are confirmed by common nodal rules.

(ii) Local Chain:

In Holochain Network, each client owns a local chain for signing the item prior to sharing it on DHT. Although, multi-party interactions are signed by individual client and committed to their respective local chains and then mutually shared on DHT.

(iii) Shared Storage (DHT Validator):

The main task of this shared storage is to confirm the provenance of each data bit by validating author signatures as well as their local chain commitments. Thus, this shared storage it is called DHT Validator or Validating DHT. Validating DHT, not only validates all the local chain commitments by individual clients but it also stores the meta-data of all individuals who are the authors of the local chains which are committed on shared storage. It also allows to join this meta-data with data elements for information publication of the local chain authors.

Figure 4, shows the working of the Holochain Technology on the base of the above described three primary subsystems. The working also shows that the Validating DHT is the core of the Holochain which takes an agent-centric view of data as the agent (client) directly deals with the core due to the built-in autonomy in its architecture and protocol.

It should also be noted that one of the major things about this working subsystem of Holochain is its client participation modalities, which are of two types:

(i) Local Chain Authorship:

This is one of the basic level access modes where you can sign your local chain, create the sequential record data of your local chain and share it on the holochain. On the basis of the validation rules set by the holochain, your shared data might be immutable or non-repudiable. Following are the complete sequence of the steps involved in local chain authorship mode:

a. Validate your own new data

b. Store the data as a new chain entry for local chain creation.

c. Sign the data and put on to the local chain

d. Index the content kept on the local chain

e. Share the data as a local chain to DHT

f. Respond to the validation requests from DHT nodes

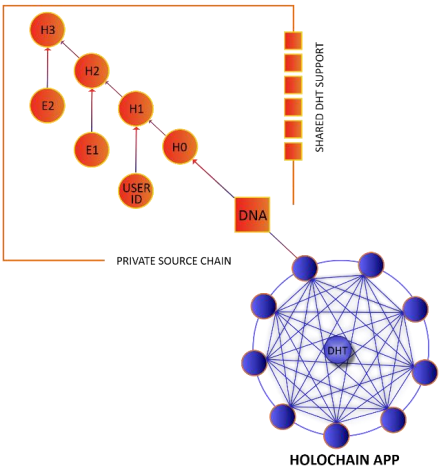

Fig. 4. Working of Holochain Technology

(ii) DHT node validation and publication:

This authorship can be considered as a superuser level privilege mode. In this mode, your node receives requests from other clients to publish their local chains to DHT data. All the tasks of validating signatures, chain links and other specific application data required in order to publish the source local chain is done at this mode.

Let us summarize the working of Holochain Technology based on figure 4 as well as the subsystems and modalities that are described above:

- There are many Holochains (H1,H2,H3 in figure 4) in every private source chain which is owned by an agent.
- Every application (E1, E2 shown in figure 4) will have its own Holochain (for example, H2 and H3 for E1 and E2 which results in cheaper hosting as every app does not require many resources.
- The user itself will also have its own Holochain and it can be seen in figure 4, where user ID is attached to H1.
- Since users are hosts, as more agents use an app, more hosting power and storage becomes available. Thus, the load decreases instead of increasing.
- In figure 4, there is only one private source chain belonging to a single agent that we have depicted. Although in reality there would be many private source chains that are connected to Shared DHT or Validating DHT. Moreover, each agent's source chain holds the app's “DNA”—the code that runs the app.
- Each app stores its data in a validating DHT creating redundancy of public data across randomized nodes.
- When nodes go offline, the DHT is self-healing and rebalances the data to different nodes.
- And if someone alters their own app code they effectively fork themselves out of the shared DHT space into an entirely different application.

Thus, the concept of private source chain ensures that the data does not remain stored centrally as each app stores the data in shared DHT or Validating DHT.

3 Conceptual Differences Between Holochain & Blockchain

From the working and architectures of Holochain and Blockchain, we can brief some of the key differences that makes different from each other.

Holochain provides a framework for developers to build decentralized applications and aims to change the paradigm of data-centric blockchains to an agent-centric system [13] while in [14] it is mentioned that the traditional blockchain stores the information via cryptographic hashes across a distributed network.

Due to the agent-centric system in Holochain there is no true global consensus maintained while in Blockchain there are consensus and proof-of-work algorithms.

Thus, in Holochain the integrity and originality of the data is maintained by each agent in the public block chain which is hosted on Shared DHT where all the private source chains of every agent is stored while in Blockchain each member independently verifies the network as a whole and maintains its integrity [15].

As in Holochain, agent maintains integrity in the public chain by maintaining various private source chains, there is no problem regarding the scalability limits as well as the decentralized applications which are hosted on Holochain can do more tasks with less resources compared to traditional Blockchain. In Blockchain as verification for entire chain is done by member using redundant copies of data throughout the network, scalability is very difficult.

Hence, when the amount of data in chains increases in a Blockchain network, the number of transactions that are processed per second becomes restricted. This is also the reason why the cryptocurrencies like Bitcoin which use Blockchain has low limits and long transaction times [16]. Holochain does not face this kind of problem as it is highly scalable due to its agent-centric architecture with the concept of incorporating several private source chains inside a public chain.

Finally, the main conceptual difference between both of these chain technologies is that the Holochain network is analogous to a hologram in that a public chain is a coherent whole which is pierced together with various different private source chains just like as light beams interact to create a holographic object or a 3-D pattern, while as the name suggests, Blockchain is a complete chain network consisting of blocks created by individual members.

In table 1 below, we summarize the differences of Holochain and Blockchain based on key features or requirements:

Table 1. Summary of differences between Holochain and Blockchain

Concept	Holochain	Blockchain
Type	Agent-Centric	Data-Centric
Data Storage	Locally in the public chain of every agent	Distributed across the whole network
Global Consensus	Not Required	Required
Prood-of-Work	Not Required	Required
Integrity	Maintained by agent	Maintained by member
Scalability	Easily scalable	Difficult to scale
Resources Required	Less	More
Transaction Time	Low	High
Limits	No Restrictions	Pretty much restrictive

4 Applications & Future Usage of Holochain & Blockchain Technology

After thoroughly investigating about conceptual working and differences in the concepts used for working in both Holochain and Blockchain, we will have an overview on applications of these technologies.

4.1 Applications and Future of Holochain Technology

According to [5] following are the applications of Holochain Technology:

- Social Media
- Identity Management
- Can be used as a currency where the complexity of the transactions is much higher.
- Holochain can also be incorporated in e-governance mechanisms.
- Can be used to implement supply chain management solutions by developing collaborative applications.
- It can also be used in various applications for economy and finance sectors.

Apart from the applications given above, there are also some Holochain Hackathons organized in past where the users have developed many exciting projects listed below [17]:

- YouTube Clone
- Reddit Clone
- Chat Apps
- Games Apps
- Social Activism Apps
- Password Management App

From this, we can say that we are having an exciting future ahead for Holochain technology where it would be applied across so many domains and popular applications.

4.2 Applications and Future of Blockchain Technology

Blockchain is already being used in many applications widely at the moment and it would be still kept using in some of the domains. Although, let us look on some of the domains where it is very much in-demand.

According to [18], following are the major applications where the Blockchain technology is being used:

- Healthcare viz. Pervasive Social Network, Body Sensor Network, Biomedical Health Care, etc.
- Finance: It used in the form of various cryptocurrencies as well as for smart contracts, mining, internet banking systems, payment, etc.
- Internet of Things: It is used for security purpose in the implementation of smart city and smart home devices as well as in providing security in all the major IoT Applications.
- E-Governance and Power grid: It is already implemented by many Governments in their electronic governance systems as well as in nation-wide power grids for robust security.
- Cloud Computing: When Blockchain is implemented in a cloud application, there is an additional amount of security that is available in it.

Moreover, apart from the above given areas, Blockchain is also fairly widely used for its security in Intelligent Transportation Systems, for smart contracts in commercial world, for authentication in supply chain management systems.

5 Conclusion and Future Scope

Holochain and Blockchain, both are such technologies which could not be ignored or put aside. Both are very powerful technologies in their own sense. Although, Holochain outplays Blockchain as it has agent-centric approach which speeds up the transaction and makes it very much scalable compared to data-centric approach used by Blockchain Technology. The world always moves towards a technology which is easier to implement and quicker to give the solution. This makes Holochain a probable successor to Blockchain Technology. Even though, Blockchain Technology is very much in usage and has been implemented across various domains in today's world, it is very much likely that Holochain may replace it as it seems very much advanced and quick from the perspective of working and implementation. However, there is still much research required in Holochain Technology, as it is just in its preliminary stage of development. Considerable work is required to develop stable platforms for implementation of Holochain Technology across various domains.

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