

Integration of Blockchain and IoT

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Abstract: The Internet of Things (IoT) is a foundational technology that is making its space in every household. It has the power to connect billions of objects together and allow the sharing of data among them. However, there still exist some shortcomings that are holding IoT back from being at its peak potential. It has a client/server-based model for storing sensitive information which is very risky as it is prone to attacks. Hence, the solution to this is implementing IoT technology in a decentralised model which can be provided by Blockchain. Blockchain is a powerful technology known for its transparency and security.

This paper talks about the issues being faced currently due to the use of a centralised system and then provides a solution to those problems by explaining how integrating IoT and Blockchain can and will lead to greater outcomes. It also shines light upon some uncovered limitations which hopefully if worked on, could give rise to a flawless model. It also gives an idea of the different devices, objects, etc., that can use this to gain maximum benefit and improve their functionality. Lastly, it mentions how this combination is a substantial approach for paving a path towards a brighter future.

Keywords: Blockchain, Integration, Internet of Things, Security.

1. Introduction

A. Blockchain

Since innovations are outlining and impacting every individual in this day and age and this is making us dependent upon the Internet for each of our activities, we need that uplifted security for carrying out daily activities. This secure environment is provided by one of the most disruptive technology: Blockchain Technology.

Blockchain is established in a distributed network and it's trusted for its extremely secure base for various applications.

"Blocks" store pieces of digital information. And as they increase in number, it forms a chain as these blocks get connected to each other.

It's a distributed ledger consisting of all the transactions that have been executed and broadcasted among all participating parties in the network. Each of these transactions is verified by the maximum number of parties in the ledger and once that is done, it can never be erased.

Basic Working of Blockchain

When a transaction is created, it's broadcasted from the

sender to the entire network, so every node on the network receives it. However, this transaction is not yet verified. After this, predefined checks are performed on the structure for validation.

Special node types called miners; they collect transactions from the transaction pool and create a new block to store the transaction. Then the block is mined, which embodies the process of finding proof of work (PoW). This is using variable data from the new block's header and performing the calculation of getting a hash that will fit the block. After this, a lot of processing is done and the transaction is validated. Once it's validated this block is added to the ledger.

The block stores the transaction, metadata, and the hash; this unique code allows one block to differentiate from the other. Each hash function connects the current block to the previous block so every block has a pointer to the parent block, which makes the possibility of a malicious activity taking place almost null. This means that the last block in the chain will hold the latest transaction.

Blockchain has the following attributes:

- It's Distributed: It creates a shared system where records are distributed among multiple connected members of the network. The data becomes visible to everyone in the network. It makes data more scalable and robust.
- It's Permission-Based: Only members who have been granted the privilege to access information can do so.
- It's Secure: The identity of an individual is hidden and represented only in the form of code to prevent exposing personal data.
- It's Immutable: All validated transactions are permanently recorded.
- It's Transparent: An entire copy of the completed transaction is stored in the blockchain and visible to everyone.
- Increased Capacity: Since it has multiple systems working together, it can increase the capacity of an entire network.

Types of Blockchain:

Public: Public Blockchains are accessible to and managed by the public.

Private: A private Blockchain is a permission-based blockchain, these networks place restrictions on which participants can participate in certain transactions.

B. Internet of Things

Internet of Things (IoT) is one of the most promising technologies which we are using in our day to day activities to enhance the basic tasks we have to do. IoT aims to make users' life more convenient by enabling them to create their own IoT automated environments because everything will be interconnected. Examples of the features that'll be coming through with the help of IoT will be voice-controlled, remote-controlled appliances, etc.

Internet of Things is an umbrella phrase that describes the various amounts of digital devices (which are continuously increasing) connected in a large interconnected network. These devices could be vehicles, appliances, mobile phones, etc.

A lot of industry specific applications require communication among various physical devices and IoT provides exactly that. Its purpose is to allow storage of data without human interaction and then making use of that data to enhance its usage in systems or adding functionalities to several systems.

According to research, there was about a 31% increase in a year from 2016 to 2017 of the number of connected devices. It rose to about 8 billion in 2017. Now, it's estimated by Cisco that there will be about 20 billion connected devices by 2020.

The Internet of Things shall be able to incorporate transparently and seamlessly a large number of different and heterogeneous end systems while providing access to selected subsets of data for the development of a plethora of digital services [1].

2. Why we need IoT and Blockchain Integration

The Internet of Things is experiencing exponential growth in research and industry, but it still suffers from privacy and security vulnerabilities. Conventional security and privacy approaches tend to be inapplicable for IoT mainly due to its decentralized topology and the resource-constraints of the majority of its devices [2].

The way it works right now is that all IoT devices store data in the cloud which acts as a central entity that provides its backend services to the smart devices. This means that all the devices have to be authenticated by the server. This is a centralized IoT platform and it tends to have various limitations:

- *Security:* This is one of the major concerns when it comes to using IoT devices and the reason for this is that when devices are connecting to the internet, they are sharing key information. This information is stored in the cloud which if leaked could give rise to a major security threat. Also, the greater the number of devices and information, the greater the threat.
- *Intrusion of Cloud:* Since all the data is stored in the cloud

and everyone is aware of this, the majority of the hackers will try attacking the cloud to gain information which again poses as a grave security threat.

- *High Cost:* As IoT is a popular and growing field, demand is also growing which builds up the cost of the devices that hold the IoT capabilities. Moreover, it's also expensive in terms of management as if the cloud was hacked into, it could cost \$50 to \$120 billion in damages.
- *Privacy:* An incredible amount of information is collected through the IoT devices and placed on the cloud and we've already seen how risky it is to have all the data placed together on the cloud. Companies have no choice but to do so and take that risk of robbing their customer's privacy if data is stolen.
- *Customer Doubt:* It's understandable that since everyone knows how IoT works they also know the risk involved with it. Knowing this, it makes customers a little skeptical about the devices when it comes to thinking whether or not the devices can actually store and handle data securely.

We can see that there are various issues that we are facing currently due to the use of a centralised system. Thus, to make IoT successful and have it reach its full potential we must adapt to a decentralised platform that can add benefits to it. Major changes can be brought upon by integrating Blockchain and IoT like reducing the computational overhead and distributing the storage over millions of devices connected through the Blockchain network. Moreover, integrating Blockchain with IoT will allow peer-to-peer messaging, file distribution and autonomous coordination between IoT devices with no need for centralised server-client model [3]. The goal of this integration is to eliminate single point failure by making the devices run on a resilient platform.

3. Benefits of Integrating Blockchain and IoT

Here's a list of a few of the advantages that'll arise once we incorporate a decentralised system with IoT technology:

- *Improved Security:* Since this is a distributed network, there's not a single point meant for entrance by hackers which makes it more secure. And as it follows hash algorithms and encrypts using digital signatures it becomes almost impossible to track transactions and then misuse them.
- *Tamper-Proof Data:* The risk is much lesser with distributed networks as it uses timestamps to provide proof and these timestamps cannot be hindered.
- *Lesser Cost:* All costs required in centralised systems and systems associated with that are eliminated and as the risk which comes with using cloud gets minimised, the cost is also assumed to be reduced.
- *Customers Trust:* Since the distributed ledgers technology has proven to be so secure, customers will have more trust and faith while investing in the IoT devices.
- *Speed:* The transaction is distributed on the network and processed within minutes at any time of the day.

- *Autonomy*: One of the greatest advantages is that smart devices can self-monitor and act independently once it has all the data and is aware of daily routines. This can be done using a predefined logic. This completely removes central authority.

To gain the benefits that result from blockchain and IoT Integration, many companies have already adopted this. For instance, IBM in partnership with Samsung has developed a platform ADEPT (Autonomous Decentralised Peer-to-Peer Telemetry) that uses elements of bitcoin's underlying design to build a distributed network of devices, a decentralised IoT [4].

4. Limitations

Even though Blockchain has an abundance of advantages, it also has its fair share of drawbacks. Some of them are listed below:

- *Scalability*: As the number of blocks increase, the response time becomes greater and it scales poorly. This could be a major setback as IoT is having an exponential growth as the number of devices with IoT capabilities are increasing by the second.
- *Processing Power and Time*: The objects in blockchain get encrypted at a particular speed which requires a specific amount of power and time whereas IoT devices have different computing capabilities and not all of them can run with the same encryption, power and time of a blockchain.
- *Lack of Skill*: Blockchain is still a relatively new technology, so fewer people have the skills for it. But IoT is spread in all domains so adopting blockchain can be difficult.
- *Legal Issues*: Blockchain allows communication and connecting of different people from different places without any sort of legal code to follow so this can pose a challenge for service providers.
- Mining is time-consuming but most of the IoT applications prefer low latency.
- Certain IoT devices have limited bandwidth so for them the overhead traffic that Blockchain protocols create is undesirable.

5. How to implement Blockchain in IoT

To integrate both these technologies, we have to initially make sure that all the devices which are connected are operating on the same blockchain network. This is the primary step as it's very important to have all devices on the same platform to enable communication among them.

Moving further, suppose someone recently made a payment through their credit card by using their mobile and this mobile is one of the connected devices on the network. This will take that transaction and broadcast it to the network so that every device on the network can view this transaction.

Since every device can view this, they will analyze this

transaction and then validate it. Then after deliberations, all the devices will come to conclusion and select as to whether or not this transaction should be created into a new block. If yes, then an identical copy of this block is added to their local ledgers allowing it to be a part of the chain with recorded time stamps which then makes it impossible to tamper with.

6. Applications of Blockchain and IoT

This integration makes it useful for multiple applications such as:

- *Vehicles*: This is a part-sensitive industry which means that it has parts brought from various vendors and it also sells parts to different buyers. So it's necessary to keep track of moving pieces and it's best done by an automated and transparent system, this is very helpful to show transactions like manufacturing, selling, buying and distributing. Also, the reason why vehicles come in the "internet of things" devices, is because they are connected to the internet for various applications.
- *Smart Home Appliances*: Nowadays, everything is connected to another thing in households. For example, the lights, the blinds, the air conditioner, etc are all connected to a mobile phone and this data is stored in a blockchain making it extremely secure and helping maintain privacy.
- *Supply Chains*: Many supply chains could benefit by using blockchain in IoT. Key information like container shipment details could be stored in Blockchains. All movement of container from source to destination can be tracked by any supply chain entities, so that shipment delay can be minimised and the missing asset can be tracked accurately [5]. Moreover, this also provides device authentication which helps verify the transactions making it a trusted approach.
- *Decentralised Machine Networks*: The change the blockchain brought was that instead of storing all data on the cloud, we now store it distributed system which allows multiple people to "see" the transaction details and verify then anytime making it more secure, compared to a central hub having all control. A decentralised machine network would be able to have an open channel for communication among connected devices by exchanging information through Decentralised Wireless Networks.
- *Health Care Domain*: Storing information in a blockchain ensures data integrity. People know for a fact that their data is not only secure but also can only be accessed by trusted sources and that this data cannot be tampered with.
- *Blockchain technologies can also be used for energy sharing among IoT devices*. This is a fairly new application and can be implemented in the following way: Taking the Internet of Vehicles (IoV) as an example, electric vehicles can absorb excess energy during lighter hours and provide energy as distributed generators during the peak period [6]. Blockchain, in this case, can be used

to provide secure trading as it will be a distributed network instead of relying on other individuals to monitor this and also efficient trading which keeps track of payments.

7. Future scope of this integration

- **Smart Contracts:** Smart contracts are powerful because they are flexible. They permit trusted transactions to be carried out among anonymous parties without the need for a central authority or a legal system. They render traceable, transparent and irreversible transactions. They can not only store data securely, but also allow restricted access to the network. Only nodes with specific access are permitted. Therefore, using smart contracts within IoT systems will result in greater efficiency and utility.
- **Regulatory Laws:** As mentioned above blockchain does not follow any legal code so hopefully in the future, there might be some regulatory laws that define ways to work with a product or technology in a particular region passed by some authorities.

8. Discussion

After reading this paper I think we've established and justified the need to integrate these two technologies. A particular domain which I think will benefit from this would be the healthcare domain. Newer technology is making human dependency diminish every day therefore since we are relying on machines to save our lives, we must at least be guaranteed that our personal data is secure and that no one has the means to tamper with it in a way that may lead us to potential data. Moreover, all these medical technologies are connected to the internet to send the corresponding updates about our health to the required database and functions. Therefore, this data must be secure to prevent the hindering of information and misuse of this personal data. This is where Blockchain would come into play to make sure that no dishonest activities take place.

An example of this is Smart Continuous Glucose Monitoring, where the glucose level in the bloodstream is continuously monitored in diabetic patients by taking regular readings. This statistic is then sent to a connected mobile phone which then analyses the data and suggests when and what quantity should the next dosage be. Hence, reducing risks that arise due to less or excess amount of insulin. This data thus should be protected to get the right amount of prescription and to not fall in the wrong hands. Similarly, many such applications would be able to help millions of people around the globe if they proved to be extremely reliable and secure.

9. Related Work

Blockchain in Internet of Things: Challenges and Solutions- This paper talks about a security model proposed by the authors to overcome the challenges they faced despite integrating Blockchain and IoT.

When the Internet of Things meets Blockchain: Challenges in Distributed Consensus- This paper talks about the consensus model and Proof of Work and Proof of Stake. After which it discusses Direct Acyclic Graph and its limitations.

Blockchain with Internet of Things: Benefits, Challenges and Future Directions - This paper gives an overview of what the process of integration of these two technologies is.

This paper gives insight to not only the process, benefits and limitations of the integration but also talks about its applications and convinces the reader that there's a need for this integration. It also talks about the direction that will be followed in this stream and what barriers need to be overtaken to drive it forward.

Lastly, I've discussed what I believe is the domain that will benefit the most and produce the best outcome of this combination.

10. Conclusion

IoT technology has spread and reached every aspect of one's life. It can connect to objects we use daily to the internet. This technology now has set up high expectations for itself.

In this paper, we established that the ongoing centralized system had various limitations and the prominent solution to eliminate most of them was the implementation of a distributed system-Blockchain. This provided secure communication in a verifiable manner. The goal of this paper was to highlight the various benefits and limitations of combining Blockchain and IoT and also specifying the applications for the same. In the end, the paper concludes by stating the future scope. I believe that with more research this can uncover a lot more traits that can be implemented in a lot more ways.

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