A Survey on Blockchain in IoT-Enabled Smart Home Network Security

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***Abstract*— In 1950s people started realizing that the value of data is much more than they knew due to which the concept of providing network security came into existence. The term Network security defines that providing confidentiality, integrity, and accessibility of data to the network. Internet of things (IoT) is a technology that is growing rapidly and can be found in most of the domains which includes smart home systems (SHS). A conventional SHS is a centralized architecture where devices like sensors, led's, voice assistants and many more are connected to a single gateway for monitoring and controlling of their activities. Due to the presence of issues like single point of failure (SPOF), rise of data loss and many other security risks in centralized architecture affects the secure data storage and transmission. Adopting blockchain-based home automation technology reduces numerous security problems which exist in the centralized architecture. So in this survey paper we walkthrough different methods of adopting blockchain in different SHS, and also we analyzed the advantages and disadvantages of blockchain-based SHS.**

Keywords—IoT, Blockchain, Consensus, Consortium, Smart Contracts, Ethereum.

1. INTRODUCTION

Recently, IoT devices are used in many sectors of day-to-day life, including Smart homes. Smart home system is one of the application on Internet of things (IoT) which is gaining more popularity nowadays., where different sensors are used within the SHS through wireless connectivity. These sensors are accessible and operated by the home owners remotely. Some of the smart home IoT devices are power switches, light bulbs, locks, and many more.

IoT devices are used in many applications. These IoT devices are used to collect, store, and share data for controlling and monitoring of these devices, hence providing secure data transmission is necessary. If not there arises security concerns such as information theft, rise in data loss, vulnerability of the devices and some other cyber attacks are possible.

Despite the limited computing capacity of most IoT devices, space can still be infected by malware. IoT botnet malware is among the most frequently seen variants. The Mirai botnet has had a major and widespread impact because of poor security and access controls present in many Internet of Things devices. Numerous Mirai versions and Distributed Denial of Service(DDoS) attacks have become more frequent as a result of the public release of its source code in 2016[1]. A real-life instance of illegal hacking in which a perpetrator attempted to obtain data from a North American casino using a fish tank was made public in 2018. Despite the casino having implemented certain security measures to identify the risks, the tank is nevertheless hacked by the hacker so that they could send data to a device in Finland[2].

The Blockchain based smart home automation gateways are proposed in order to solve the issues that is present in the centralized smart home architecture and also protect home automation gateways against cyber attacks. Blockchain can be defined as a distributed ledger that tracks and stores data or information of virtual transactions and so forth[3]. Secrecy, accessibility, integrity, and single point of attack can be avoided or reduced by implementing blockchain in the smart home system (SHS).

There are three ways that blockchain is currently being used. The first is public blockchain, also known as the permissionless blockchain, in which it allows everyone to participate in block verification and it is the massive network of interconnected nodes. It is open to anyone including miners, users, developers, and members of communities. The other method uses a private blockchain, which is also called permissioned blockchain that may only be accessed by pre-defined group of the known organization[2]. Consortium blockchain technology, which uses hybrid of public and private blockchain to implement blockchain, is the third method. In this only a predetermined group of nodes are used for block validation[4].

According to[5], the centralized conventional IoT model are compared with the blockchain model. It was found that blockchain based model was more attractive because the issues related to requirements for security in smart home network was not found in blockchain. In centralized architecture of IoT model IoT devices are connected to a single smart home gateways as mentioned in [6]. For IoT devices, a decentralized data management system is used with smart contracts used to enforce all data permissions and the blockchain used to store the audit trail of data access. Without the need for centralized system, multiple nodes can specify rules and regulations to judge their interactions through the use of smart contracts applications, which are independently enforced in the blockchain. In [7], they offer framework that stores the hash value in block and raw data is stored in storage platforms using trusted execution environment.

Many blockchain based smart home architecture are designed using Ethereum smart contracts. Ethereum is a public blockchain-based distributed computing platform which has it's own language such as Solidity and Serpent developers can write and compile using this language [8]. Ethereum can be used to combine computing systems with blockchain. This type of blockchain has difficulty of implementation and has scalability issues. It also need huge storage and also consumes more energy.

The structure of the paper is further classified into following sections: Section 2 of the paper describes the background and related study, then section 3 consist of Literature review. The paper ends with conclusion and future work in section 4.

2. BACKGROUND AND RELATED STUDY

2.1. Blockchain

Blockchain is defined as a decentralized and distributed public ledger technology in peer to peer network. It uses a linked block a structure to store and verify the data and creates a tamper-proof digital platform for storing and sharing data by using a consensus mechanism to synchronize changes in data [9]. Every request is recorded in a series of blocks, each of which has a distinct digital signature for use in verification. Blockchains are the best option for storing sensitive data due to the fact that the ledger is created and maintained by everyone involved in the system equally, eliminating the need for a central controller to oversee operations.

Consensus algorithms are used to keep the same transaction records in all the nodes, which are consisted of the proving work of the transaction and the selecting policy of the block [10]. Few common consensus algorithms are PoW (Proof of Work) and PoS (Proof of Stake). The PoW is a mechanism in which the majority of nodes on the network decide on a single state it is said consensus is achieved. PoS is an alternative to PoW which reflects on the holding assets of the participating nodes.

2.2. Smart Home Network Security

Smart homes are automated structures with detection and control equipment already installed, including HVAC (heating, ventilation and air conditioning), lighting, hardware and security systems. These contemporary systems sometimes referred to as "gateways", comprise switches and sensors that interact with the central axis. IoT controls the network connectivity of these control systems, which have user interfaces that communicate with tablets, smartphones and computers. To solve the problems present in the centralized SHS numerous solution exist, blockchain is one of the best solution which exist. Blockchain in SHS removes the single central system and replace it with distributed system where each node in system get equal priority. We can implement a blockchain based SHS using Public, private or consortium blockchain.

Public blockchain based architecture for SHS

The authors of [11] by combining both blockchain and IoT proposed a model for smart district and provide user access to the power grid of the district. They developed a prototype where authorized users are able to work in the power grid systems through blockchain. Solar panels are setup at home and the owners can trade energy over the blockchain mechanism. Observing this system gives us information about various technical needs to implement a blockchain-based smart home system (SHS). This implementation could be a prime example of how blockchain-based IoT applications can be adopted and reduplicated in real world.

According to authors of [12] we can speed up the processing and display appropriate performance by implementing a "efficient light weight integrated blockchain (ELIB)" model for IoT systems. This model was created using public blockchain which contains two nodes overlay and smart home, operates in three layers namely consensus mechanism, certificateless cryptography, and distributed throughput management scheme (DTMS). Public permissionless blockchain make use of expensive consensus procedures, such as proof of work (PoW) proof of stack (PoS), or protocols that demand specialized hardware, like proof of elapsed time. In IoT systems where devices are diverse and power constrained, such standards do not apply. The throughput and latency demands of IoT applications, which frequently call for hundreds of transactions to be committed to the ledger within milliseconds to seconds, cannot be met by them either.

Private blockchain based architecture for SHS

A private blockchain is also called permissioned blockchain which is deployed within the organization or shred between known predefined group of participants. The writers of [14] proposed a 3 tier architecture for efficient and secure information processing. The three tier architecture includes IoT devices connected to raspberry pie, fog computing, docker containers which provides a real-time analysis and helps in monitoring of data. This proposed architecture guaranteed that confidentiality, availability, and integrity of data and also resolved scalability issue which is present in public blockchain. This also secures the architecture from Distributed denial of service (DDoS) attacks.

Consortium blockchain based architecture for SHS

A consortium blockchain is used as the distributed ledger to record all IoT devices and their services. It serves as the main channel of communication for IoT services with their users and provides significantly greater performance and scalability and then permission-less public blockchains. The IoT network may decentralize eliminating the centralized servers that are frequently SPOF. Additionally, to protect IoT services from unwanted access, the platform can make use of access control features added by consortium blockchains. Finally, because every modification to IoT services, as well as every service request and answer, is permanently recorded on the ledger, the blockchain effectively functions as a data historian for data audits [13].

There exists a modified or hybrid consortium blockchain system called "Homomorphic consortium blockchain (HCB)". This blockchain system uses a homomorphic encryption algorithm which allows people to perform algebraic operations on the secured data which is in the form of cipher text and get encrypted results. This helps in maintaining the privacy of private or secure data [16]. The consortium blockchain differs from private blockchain, consortium blockchain uses the concept of consensus algorithm to verify the transactions. This methodology

helps SHS to use the pros of both public and private blockchain.

3. Literature Review

Table 1 Advantages, disadvantages, and methodology of existing blockchain-based models

Related Studies	Advantages	Disadvantages	Methodology
[5]	• Despite the existence of time consuming process blockchain can maximize the efficiency by automating them • The edge server boosts system scalability by outsourcing labour-intensive processing tasks and aggregating data to the cloud safely and securely via a differential privacy method	• The current industry faces serious transparency problems. The organization made an effort to impose more laws and restrictions. With blockchain, smart homes operate on a fully decentralized network, eliminating the need for centralized control and enhancing system transparency	• The users get access to a smart home through a attribute based access control authentication technique • Which allows real-time communication between home users and the blockchain node
[11]	• Security and privacy is provided using cloud storage and overlay network for coordinating data transaction with blockchain	• Difficulty of interoperability of different home devices. • Interoperability, the ability to communicate between other devices from different manufacturers represents a crucial condition for the development of smart home	• Blockchain uses a token called as a consensus mechanism, which generates a hash with information contained in the specific blocks
[6]	• Provides the solution to minimize . Secrecy, accessibility, and integrity issues of the various IoT and centralized gateways	• Difficulty in Implementation • Scalability issues	• Usage of SHA2 encryption technique to resolve confidentiality and authentication issues
[7]	• Decentralized access policy provides data integrity and security	• Scalability issues	• Ethereum is used for evaluate the transaction • It uses a framework that stores the hash value in block and data is stored in storage platforms using trusted execution environment
[10]	• Delegated proof of node technique or S-DTS is used to provide safe and efficient transmission for large IoT environments and other IoT devices	• Limited number of witness can lead to centralization of network in DPoN	• Delegated proof of node is used to implement blockchain
[12]	• ELIB model meets the necessitates of security and privacy	• High energy consumption • Only suitable for few applications	• It mainly operates in 3 levels namely consensus algorithm, CC model and DTM scheme • The overlay network generated by ELIB model has highly equipped resources which can integrate to a public blockchain for privacy and security verification
[14]	• It gives real-time analysis with monitoring of data • Scalability issue of blockchain is resolved	• High implementation cost • High power consumption	• It used IoT, Fog computing, docker containers for the efficient processing of information

[15]	• Sharing of data without an intermediatory between trusted and non-trusted stake holders	• Since Ethereum is used implementation cost is high	• It uses Ethereum based public blockchain storing the transactions
[16]	• The verification of the newly entered blocks can be done by all nodes	• High implementation cost • Require private key to access the information stored by the blockchain, if it fails the wallet will be in risk	• A modified smart home network is built with the use of consortium blockchain architecture
[8]	• Easy synchronization between IoT devices with other devices because of distributed ledger	• Security is compromised due to involvement of third party • Ethereum is not fast enough for some time sensitive domains	• RSA encryption technique is used to manage keys, where Ethereum stores the public key and individual devices stores private key

4. CONCLUSION

This paper introduces the application, existing problems, and solutions for smart homes based on a blockchain architecture. Firstly we found several concerns involved in centralized smart home architecture such as confidentiality, integrity, and Distributed denial of service (DDoS). Blockchain was integrated into this architecture to resolve the issues in the centralized architecture. Secondly, we summarized how public, private, and consortium blockchains are integrated with smart home systems. Further, we discussed the different consensus mechanisms used in the blockchain. We have done a comparative analysis of work done by different researchers in this field and found that issues found in centralized architecture were resolved by distributed systems but a new problem of scalability has arisen in most of the proposed architecture. Further research can be done to resolve the scalability issue present in the distributed architecture.

CONFLICT OF INTEREST

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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