



# Blockchain Use in Home Automation for Children Incentives in Parental Control

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## ABSTRACT

Application of IoT (Internet of Things) is expanding rapidly as internet connects things in our homes and our personal devices and even our body, provides ease, entertainment and comfort to our daily lives. However, as everything personal is connected, security and privacy becomes a major challenge. Blockchain-based IoT can provide a completely trusted and transparent environment with its tamper-resistant data structure, timestamp, data encryption and distributed consensus. Since cryptocurrency is the first application of blockchains, most blockchain mechanisms like Ethereum provides token-based peer-to-peer payment system that allows payment using a custom currency which enables IoT devices to pay or receive token without a third-party inclusion. In this paper we proposed to apply blockchain mechanism to education/discipline of children at home by through token-based parental control in which parent can encourage good behaviors and discourage bad behaviors of children via tokens transferred via blockchain network. Current parental control is implemented in operating systems of smartphones that only prohibits the abuse of smartphone games or inappropriate web sites. However, this token-based parental control pay tokens to children with good behaviors that allow them to play or watch the proper contents as their rewards. Devices at home like television and computer are connected to the blockchain and accessible only when the user have a sufficient amount of tokens. Children are given incentives in term of token by their parents if they do their homework properly or help their parents. Besides that, smart contract feature in Ethereum allows application to be programmed in a blockchain

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enables monitoring the activities of children through blockchain. This paper introduces the design of the token-based parental control by using smart contract schemes of Ethereum blockchain with a simple smart home setup as a proof of concept.

## CCS Concepts

•Computer systems organization→Embedded and cyber-physical systems •Networks→Network architectures.

## Keywords

IoT; blockchain; parental control; smart home.

## 1. INTRODUCTION

Internet of Things (IoT) started to emerge from nowhere thanks to the inexpensive internet and cloud today. Everything revolves around automation, data exchanges, cloud, cyber-physical systems, robots, Big Data, AI and (semi-)autonomous industrial techniques further motivates the generation of IoT devices [1]. Some reports [2] predicted that there might be up to 29 billion connected devices by 2022 with 16 billion of it is a short-range device and smart home [3] is a part of that short-range device, the number of which surpassing mobile device by twofold. Smart home allows home appliances (such as television, air conditioner and refrigerator) to be connected to the internet and providing innovative and smart service to humans [4]. We can remotely control our home devices over the internet and information about our home can be directly reach to our smartphone.

IoT device generate, process and exchanges a lot of safety-critical data and privacy-sensitive information hence it is an appealing target of various cyber-attacks [5]. Many state-of-the art security frameworks are highly centralized and not necessarily suited for IoT because of the difficulty of scaling, many-to-one nature of traffic and single point of failure [6], [7]. Centralization also forces us to trust the provider of a service. Sometime, controversial event may happen such as the Facebook-Cambridge Analytica scandal where user private data is compromised [8]. As for smart home device, it is more trivial to protect and secure our privacy in home, place that very private and personal. To

guarantee a completely trusted, transparent environment, we propose a decentralized solution for smart home using blockchain. Blockchain is a technology used in cryptocurrency such as Bitcoin, provides an attractive technology for addressing the security and privacy challenges in IoT. Advantageous features of Blockchain are: decentralization, anonymity, and security [9]. These can be beneficial to IoT adding more security layer and relieved dependence on central server. It also provides tampered resistance data structure by timestamp, data encryption and distributed consensus. Not to forget that removing the centralization can reduce the cost of maintenance.

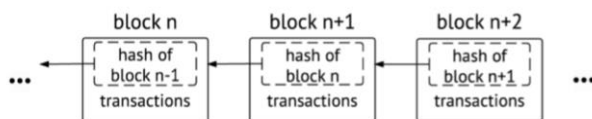
In this paper we will discuss on detail of blockchain-based smart home in our design. We first start by how the IoT devices are initialized and how data exchange (communication) between devices is handled. In blockchain [10], data is stored in a chain of block with timestamp. Any new change to the blockchain can be done with transactions where node (device that participate in blockchain) broadcasts which is use as a way of communication. The second generation blockchain introduces us with intelligent contract like Smart Contract in Ethereum [11], makes the blockchain easier to use distributed application programming and speed up the transaction speed. With this feature, certain data or parameter to be transferred in blockchain can be programmed to be modified by certain device (i.e. temperature value only can be updated by temperature sensor) resulting in more organized data control in the blockchain. Furthermore, Cryptocurrency which champs the blockchain world can be applied child discipline management which can introduce a new way to make use of smart home technology in home.

The rest of this paper is organized as following: Section 2 we introduce blockchain and how it operates in a smart home as a cloud-free setup. Section 3 presents an application of a blockchain that can be applied in house and how it is setup. Finally, section 4 concludes this paper.

## 2. CORE COMPONENTS

### 2.1 Blockchain

Blockchain is a distributed ledger or distributed database [9] which was introduced by the inventor of Bitcoin, Satoshi Nakamoto. It started when Satoshi Nakamoto wanted to create a currency which does not rely on a third party to process the electronic payment in this Internet era. Dependent on an institution or centralized authority suffers the inherent weaknesses of the trust-based model. Corruption or security breach can poise vulnerability and distrust. Blockchain begins with a timestamp server. A timestamp server works by taking a hash of a block of items to be timestamped and widely publishing the hash, such as in newspaper [10]. Each timestamp includes previous timestamp in its hash forming a chain, thus called a blockchain as shown in Figure 1. It is like a log whose records are batched into a timestamped block [9].



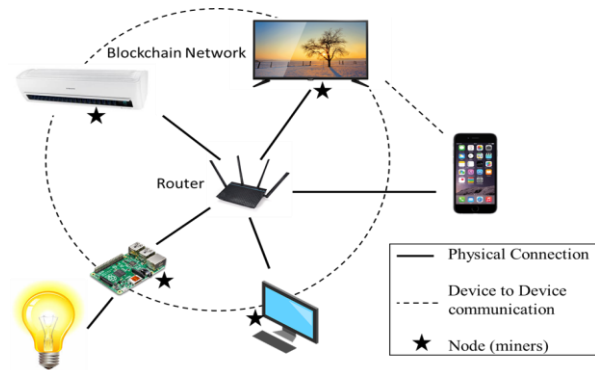
**Figure 1. A blockchain data structure that will be duplicated across the blockchain network [10].**

The distributed part of the blockchain is the decentralized network which is formed from multiple member and holds the replicated

blockchain. They are connected in Peer-to-Peer manner and are called nodes. These nodes often called as miners validate any transaction or changes to the blockchain and forge the new block to the chain. Any transaction can be made through these nodes. The transaction will spread throughout the network and each node will agree and validate the transaction and came to consensus. Miners need to solve a ‘puzzle’ with randomly generated guessing the right number that will make the cryptographic hash SHA-256 result [9], [12]. The node succeeded this will be granted proof-of-work (PoW) and gets to forge the new block. A small entity has a limited amount of resources and it need to have a stronger computation power compare to 2/3 of the network in order to take over the blockchain. This ensures the security of the blockchain where the content is hard to be tempered. Blockchain can be both public (open to all like bitcoin) and private (only selected members are allowed). Pair of public and private key are used to interact with the blockchain and can be referred as a personal account. Blockchain 2.0 introduces smart contracts which actually run other distributed applications directly on top of the blockchain demonstrated by Ethereum Blockchain [13].

### 2.2 Blockchain Integration in Smart Home

A typical IoT environment usually requires a center server for recording data and analyze. This requires trust in third party company that runs the service if it runs outside the house or relies on central hub that runs inside the house. Either way if a centralized server is hacked, the data might be compromised, and fake data can be inserted to fool the user [14]. The worst case is when the cloud server is down the whole system might need to shut down and stop operating. However, with blockchain setup in a home, it eliminates the need to rely cloud server to run the smart home environment.



**Figure 2. Blockchain-based Smart Home overview.**

Based on Figure 2 each smart device is connected in a same blockchain using peer-to-peer (P2P) through a router. Since personal trustless is the aim here, private blockchain is used to allow only home connected devices. Devices equipped with single board computer (SBC) such as Raspberry Pi as the heart and Computer is installed with a blockchain client and help to maintain the blockchain operation. Such device also can be called as node or miner. This is important as it is the key to the distributed nature of the blockchain which provides advantages previously mentioned in Section 1. Other devices including the nodes will have their own set of public and private keys to interact with the blockchain. Devices can broadcast their transaction from a node to interact with the blockchain and eventually all node will agree to the transaction made. The use of blockchain here is to replace the need to install a central server. As a result, it becomes the way for the devices to communicate, data to be exchanged and

stored. Smart contracts can be programmed such that one device can request data from other device and handle the data gathering process. For example, there are temperature sensor and an air conditioner that need to communicate. Smart contract can be programmed so that it will listen to the air conditioner to request temperature. If requested, then the smart contract can ask sensor to tell the temperature and hand it over to air conditioner. Same thing can be applied to user interaction, specific smart contract can be programmed for certain interaction and it easily can be done because blockchain like Ethereum is Turing complete [13], meaning it can perform programming similar to typical programming language like C++ or Python.

This cloud-free setup helps to remove the need for a centralized cloud which in turn reduce in maintaining cost, improves security and scalability [6]. Blockchain also bring handful of feature and its most popular use, cryptocurrency can change how certain things like managing children in the house is discussed in next section.

### 3. APPLICATION

#### 3.1 Blockchain-Based Smart Incentive for Children at Home

Getting a blockchain as a backbone network to Smart Home brings a wealth of features that we cannot achieve with a traditional centralized computer network. Business and finance are widely common in term of usage of blockchain [15]. It is not surprising as Bitcoin, the one which popularizes the blockchain, is a finance utilizing blockchain to solve distrust and double spending issues written in its white paper by Satoshi Nakamoto [10]. Even though, in just 10 years from the launch of Bitcoin, cryptocurrency become very popular today and it pave the way of future of trusted payment. Although Ethereum blockchain was built for decentralized application and smart contract, it is still a Token-based blockchain based on Bitcoin and uses POW similar to Bitcoin to handle transaction but with improved performance and scalability [13]. Blockchain-based Smart Home can abuse this strength and token feature instead of directly bringing the same Bitcoin or Ethereum money to our home but creating a virtual currency for home use only.

Currency can be created for virtually everything. Usually people sees it used as money but what if it can be used as a form of incentives. Household with children is hard to manage sometimes. Parents need to teach children to be good and discipline. Scolding is one way to do it, but it is not a great thing to involve negative emotion. There are harmful effects of physical and verbal punishment, yet it destroys self-esteem, create anger, interfere with learning, and damage the relationship between parent and child [16]. Physical punishment in the longer run it tends to increase the probability of deviance, including delinquency in adolescence and violent crime inside and outside the family as an adult [17]. Reward can be seen as the better way to promote a child discipline [18]. For example, a child can be forced to do some homework to be rewarded with time to spend on their favorite television show. This method makes them inspiring and motivated to do their work in a good positive way. Blockchain fit itself in handling this kind of work incentive for children at home. We can make a custom cryptocurrency for children to use to get themselves their reward at home and using blockchain, it is distributed results in reduced cost which incur when having a central hub instead.

With home devices linked by Ethereum blockchain, the foundation for a cryptocurrency is already there. We need to

create a coin that works as incentive and define how the operation work within a blockchain equipped smart home. Figure 3 shows an overview of a Blockchain-based Smart Incentive for children in home. Every device, children and parents participated in this system will have their own wallet to keep the coin called Playcoin. We call it Playcoin because it is used by the children to enjoy their playtime or past time by watching television or playing video games. For this system to work, children should be able to receive their coin and spend it where the machine such as television need to be able to receive and react to it by allowing usage. Besides that, there are two ways for children to receive their Playcoin, by their parents and by the machine.

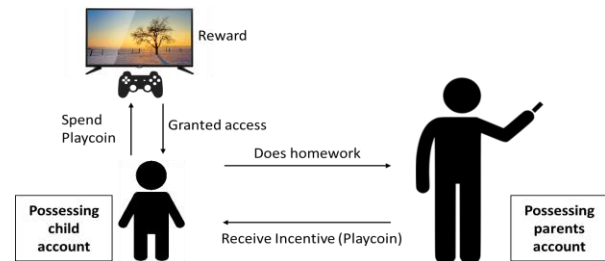
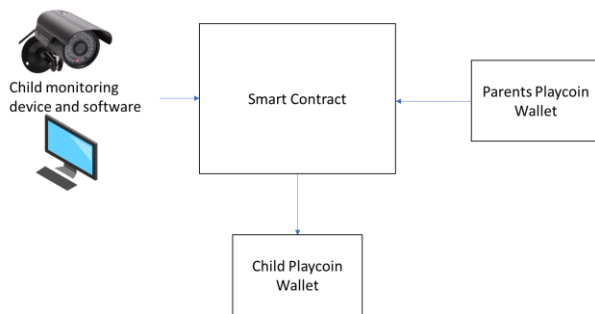


Figure 3. An overview of Smart Incentive operation.

Starting off with method of receiving Playcoin, the operation is almost similar to typical cryptocurrency like Bitcoin and Ethereum. Each device in a blockchain keeps track of the account balance of each participant. Since each device is a part of maintaining blockchain they are automatically having their account that can stores coin. Since this is a private blockchain runs in a private home, the owner has full authority to setup this system. The owner/parents account should be programmed with a huge amount of Playcoin when the system is initialized. Doing this give the parent the ability to transfer it almost infinity times for long term. Parents can use their smartphone to connect to a blockchain node (any blockchain-based smart devices) through a P2P connection and using their private key stored in their smartphone, they can send Playcoin to their children by their public key. Children then can use their smartphone with their private key to transfer the coin to television when they receive coin from their parents. The television need to have a software stack installed to achieve this. The parental control software running in the television operating system requires check from blockchain network on their current account balance. For an example, if the children make a transaction to send Playcoin to the television, the parental control software need to be able to know there is an increase in account balance and authorize the children to watch television or otherwise revoke their access if the amount is not changed or not enough. Of course, parents will have full access with some kind of password protection applied to the operating system. Same operation can be applied for the parental control software in game console or computer.

Getting incentives from parents need observation by them and sometime parents are not around home for observation. Receiving incentives also can be programmed to be automated with smart devices around the house as the eye to the children. This is where another advantage of blockchain-based personal smart home comes into play where information about children inside house is protected and secure within the house. With the rise of machine learning, surveillance camera can be programed to observe the behavior of the children. These cameras can pick up children that doing their homework or house work and automate the incentive giving process. Smart Contract flexibility and automation [9] is crucial in this situation as we can program so that parents can

automatically transfer Playcoin directly to their children when their absent. The way that it can be program is if camera says child does work, send the child a certain amount of coin. The limit that it can send in one day also can be programmed directly in order to make sure that the children do not get excess amount of work incentive. Figure 4 shows how Smart Contracts helps to automate the transferring of Playcoin. Smart contract is programmed so that it waits for monitoring device to inform it that the children did their homework and sign off a contract to transfer Playcoin directly from parent account to the child account without authorization of the parents. Moreover, computer homework also can be part of this. A software can be program to track homework submission which helps to achieve the same result using the same Smart Contract which can become another alternative to track the children commitment to do their work before enjoying their life.



**Figure 4. Smart Contract in automate coin transfer.**

## 4. CONCLUSION

Blockchain is getting a lot of attention lately because of the rapid growth of connected device and cryptocurrency. The huge influx of connected device raises the question of security and scalability. We proposed a cloud-free personal smart home by leveraging the security and privacy by using a blockchain technology. We presented how devices communicating and exchanging data using blockchain. Smart Contract brings the flexibility in programming the blockchain to behave as we like and reduce in complexity in setting up a smart home. By eliminating a centralized cloud server, we can solve the trust issue on third party and a single point of failure at the same time reduce the cost of maintenance. Cryptocurrency provides new way to interact with devices at home and allows to make policy for children incentive at home. Children is rewarded with Playcoin when they done some thing good like doing their homework.

To the best of our knowledge, this research is our first work to provide an interesting and useful application of blockchain-based smart home technology. This is the foundation for us to investigate more about the implementation of the blockchain in smart home and its limitation on smart devices.

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