Available online at www.ijpe-online.com

International Journal of Performability Engineering

vol. 15, no. X, Month 2019, pp. XXXX-XXXX
DOI: 10.23940/ijpe.19.XX.pX.XXXXXXXX

Blockchain for Collaborative Creation System

Guoyang Pan[a,b], Yi Yang[b], Guoqing Li[b], Jian Wang[b,*] and WeiXing Huang[b]

[a] School of Artificial Intelligence, University of Chinese Academy of Sciences, Beijing, 100049, China
[b] Institute of Automation, Chinese Academy of Sciences, Beijing,100190, China

Abstract

The collaborative creation model generates tremendous application prospects. In order to improve efficiency and reliability of collaborative creation, we propose a blockchain mapping method for the collaborative creation application system. We use blockchain to store tree structural content of collaborative creation. It makes creations easy to trace source and assign rewards to individual contributor impartially and trustfully.

Keywords: blockchain; collaborative creation; crowd sourcing; content traceability; application system

(Submitted on June 15, 2020; Revised on July 15, 2020; Accepted on July 15, 2020)

1. introduction

With the development of the blockchain system such as Bitcoin [1] and Ethereum [2] and so forth, as the underlying technique of these systems, the blockchain becomes one of the most attractive techniques in the data storage area. The blockchain is a decentralized and distributed database, which stores the transaction record between two peers, making the data not be tampered or forged. The transaction is an general concept and it can replaced by recordings or any important data we need to restore. Blockchain actually realizes the credible transaction in the distributed systems, and is deemed as the technique which will change the whole internet and financial industry.

The crowdsourcing is a combination contraction of crowd and outsourcing, which means many individual crowds work on the certain task which is published by the requester. The collaborate creation is a special kind of crowdsourcing, which concentrate on the area of book creation, painting creation, musical creation and so forth. A collaborative creation platform can connect the crowds together to accomplish tasks or projects. It makes full use of public resources and crowds who take part in the tasks and projects. Individuals also obtain corresponding rewards from creations in return.

Individual creation has its own special pattern. A creation consists of many section or chapter parts. To keep the continuity of the whole creation, every small part is based on the previous part and could have many versions written by different creators. These small parts form a multiple-layer tree structure.

Although there are several successful collaborative creation platforms [3][4] in industrial and academic applications, several problems exist in the current system.

First, the credibility of traditional centralized collective creation system is based on the third party guarantee institution. Authors' personal privacy and creation property can not be protected very well. According to incomplete statistics, in China, about 6.5 billon item data have been divulged in 2017. Nevertheless, if the third party management were bribed or the

* Corresponding author.
E-mail address: jian.wang@ia.ac.cn

database were damaged by unpredictable attack, the data in the collaborative creation platform will be exposed to the dangers and ruins.

Second, a project on the collaborative creation platform may be accomplished by many participants, and furthermore, some subtasks might have dependencies and orders. As mentioned above, the collaborative creation have tree structure and each route from root to leaf represents a version of creation. If a version of the creation need to be published or exported, related authors should get some rewards. Under this circumstance, managing the contribution of individuals in a task and distributing the rewards efficiently become a tough problem.

Blockchain technique with its unique features is suitable to tackle this two problems mentioned above. Its encryption mechanism can protect creation from being divulged and its traceability mechanism can find out the contribution of a author in a task on a long creating period.

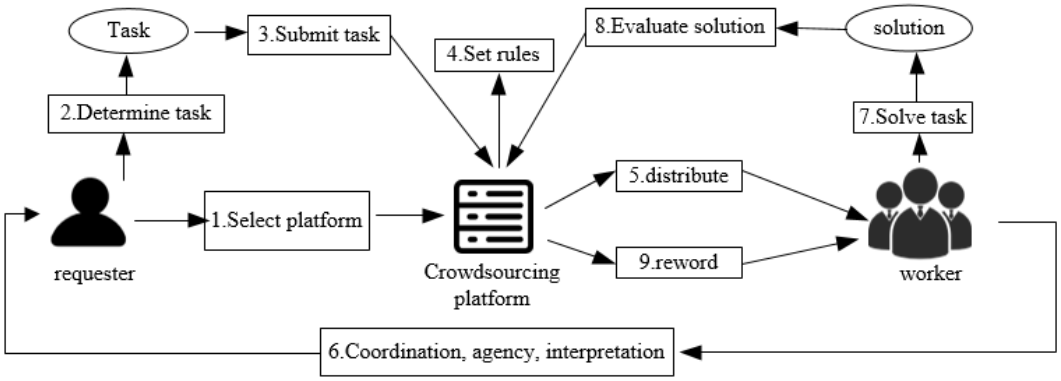

Figure 1. Structure of the crowdsourcing

In this paper, we propose a new platform which apply blockchain technique in the collaborative creation, which still works on crowdsourcing with similar tree structure. This proposed platform can manage the tree structure creative procedure very well in a unique data storage pattern with blockchain technique, and then solve existing problems. With the reliability of blockchain, platform can accomplish trusted traceability from the task information and distribute rewards to the crowds according to their contribution impartially.

This paper is organized as follows: Section 2 introduces the background of blockchain and collaborative creation area. Section 3 introduces the overall structure and utility of this platform. Section 4 discusses the traceability and distribution mechanism of this platform. Section 5 summarizes the paper and gives the contribution and limitation of this paper, then give the research outlook.

2. Background

2.1. Blockchain

The blockchain technique originated from the foundational paper published in the 2008 in the cryptographic mailing group by a scholar named Satoshi Nakamoto. The initial application of blockchain is bitcoin, an excellent peer-to-peer electronic cash system. Such kind of programing digital cryptocurrency system is deemed as blockchain mode one. With the development of blockchain technique, programing financial system and the programing society, which are deemed as blockchain mode two and mode three [5] separately, comes to the light and has tremendous application scenario.

Technically, blockchain is a distributed database with linear chain storage structure. As shown in Figure 2, there is a block head and a block body in each block. The block body is used to store main data, which depend on the practical application. The data structure in the block body is a Merkle tree, in which data information is stored in the leaf nodes. While the no-leaf nodes are designed to testify whether the data in leaf node is correct. The block head is used to store the block

information, which contains a timestamp, a nonce, a reference to previous block and the root node of Merkle tree. The block head contains the symbolic information of the block.

Due to the proof of work (PoW) consensus mechanism, any block can't be generated without using lots of computing power to find a appropriate number. If an attacker want to counterfeit a block in the blockchain, he must possess at least 51% computing power in the whole system to forge a fake chain to substitute the original chain. There are some other kinds of consensus mechanisms such as PoS [6], DPoS and so forth protecting the reliability and immutability of the blockchain.

Nowadays, blockchain technique is used in the area of finance [7], Internet of Things(IoT) [8][9][10], public and social services [11], reputation system [12] and security privacy [13][14]. In the foreseeable future, it will have more groundbreaking applications to influence the daily life.

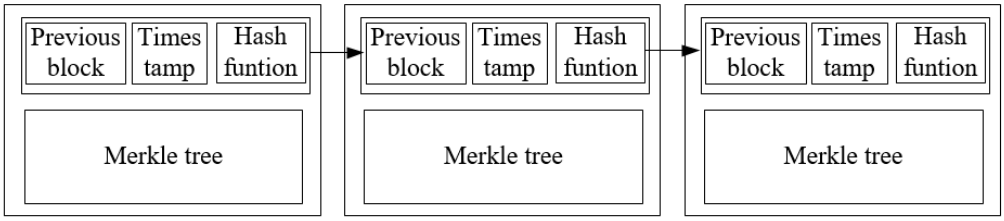

Figure 2. Image list with the same label

2.2. Collaborative Creation

Collaborative creation [15], as well as crowdsourcing, allows individuals to cooperate together for finishing a task or project. The task [16][17] can be divided into several subtasks. Certain subtasks may implement independently, while the other subtasks may not start up until corresponding conditions are satisfied.

Collaborative creation mode makes full use of spare resource of crowds. Furthermore, it also provide job opportunities for crowds to get rewards. When the creators' creations are accepted or purchased by the business entity, people who took part in these creations will receive rewards for their labor achievement.

On the other aspect, collaborated creation mode allow people to cooperate together at different position. Connected with cloud platform, creators can communicate each other for some advice and comment.

3. Platform Structure

3.1. Platform Architecture

Figure 3 shows architecture of our proposed collaborative creation platform. Three entity sets connect and collaborate together to form the comprehensive system.

Crowd creator module lay on the top layer. One creator cooperate with some creators through a certain task, while this creator may cooperate with some other creators through other tasks. The relationships among each individual crowds constitute a complex network. Creator U_i need to register account to became a legitimate entity. After that U_i will receive unique identifier Id_i and public key, private key, and certificate, marked as PUK_i, PRK_i and $CERT_i$ respectively. Creator *Ui* ask a wallet address for system and system will generate initialization list.

$$\{PUK_i, PRK_i, CERT_i\} \tag{1}$$

Subtasks lay on the middle layer. A collaborative creation task consist of many constituents which are called subtasks. There are dependency relation between subtasks. For example, the subtask B can not begin until subtask A has been finished. We call subtask A and B have dependency relation. Hence, each creation is related to a tree structure, different route of the tree represent different version of creation.

For instance, suppose that Figure 3 represent a book collaborate creation system. Task 1 and 2 represent book 1 and book 2. Creator 4 is the author of the fourth chapter of book 1, because creator 4 is connected with the fourth level of the tree structure in book 1. Meanwhile, creator 4 is also the author of the first chapter of the book 2. And Creator 5 complete many chapters of the book 2, which even are the different versions of book 2.

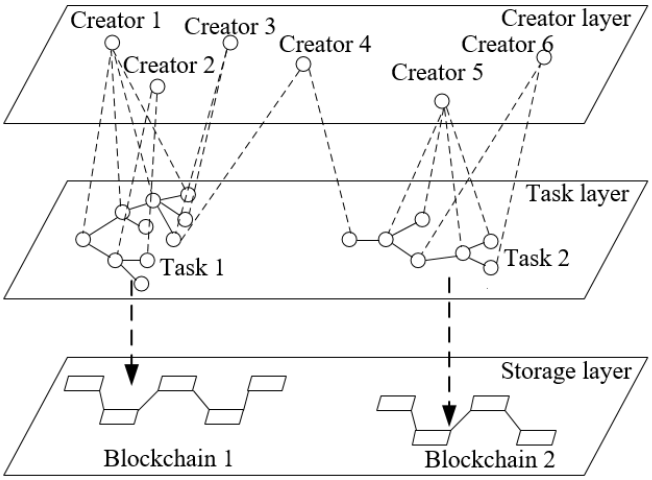

Figure 3 Relation between constitutes of structure

In order to promote the quality of creations, we lead competition mechanism into the platform. Many creators can act on the same subtask concurrently. This entails that the creative mode has tree structure. Figure 4 shows the tree structure of a collaborative book creation task. Each layer of the tree represent a chapter of the book, which have many versions written by different creators. A sub path from a root node to a leaf node is a version of this book. Each path can be accomplished by one creator or different creators. Consequently, if a new creator want to continue the book, he can choose any version of this book to begin with.

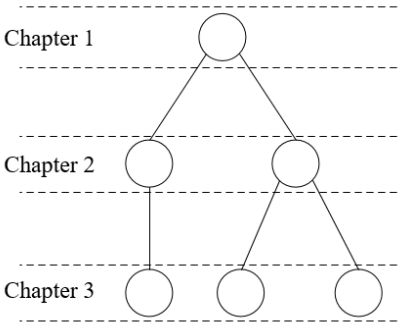

Figure 4. Tree structures of creation with different versions

In the third layer, each blockchain is related to a corresponding task. With the growth of collaborative task tree, the relation between creators and subtasks becomes complicated. To ensure the working creations are stored correctly and are difficult to be tempered or copied, in the third layer we use blockchain technique as storage carrier. Blockchain needs many agents to provide their computing power to generate the new block. As shown in the Figure 5, alliance chain consist of public agent server and private agent server. Public agent server keeps working all the time, which is usually maintained by third party company. It can prevent the condition that all of the private agent server are out of line. Some of the private agent servers are the creators, others are volunteer agents. They are connected with internet to produce new block under proof of work mechanism.

If we are interested in one version of creation, accompanied with timestamp in each data block, we can trace the blockchain from leaf node to the root node in collaborative task tree to find whole creation result.. The mapping rules from tree nodes to blockchain nodes will be introduced in the section 3.3.

3.2. Structure of Collaborative Task Tree

The structure of collaborative task tree is a typical multitree structure. The root node contains the basic demand and regulation of this task, which is a reminder to the succeeding creators as a guiding ideology. The new creators have two kind of operation about the existing creation. They can adapt or continue the creation from a existing creation node.

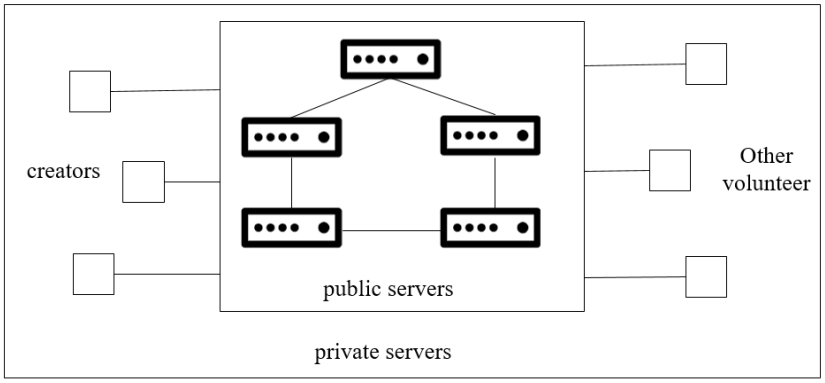

Figure 5 Structure of public servers and private servers

As shown in the Figure 6, if new creator want to continue the creation after node A, system will generate a new node as the child node of node A. Content in the ancestor node of the new node has already been constant information.

As shown in the Figure 7, if new creator want to adapt the creation based on node A, system will generate a new node as the brother node of the node A. The adaptation operation is not a simple rectify operation. Original version node is still in its original position. System forks a new node which contains original content and new creator can then rectify it at his will.

During the rectifying and continuing process, system provide for creator a draft to operate. Any rectifying and continuing recording will not be updated to the blockchain temporarily. After fully satisfy with the content of the creation, creator can choose to submit the subsection of task. For fear of plagiarism, system will compare the similarity of this node with existing nodes and reject the plagiarism nodes.

The content of task as well as information of block head will be added in the blockchain via Proof of Work (POW) consensus mechanism. POW consensus mechanism allow agent to provide its computing power to solve an time-consuming math problem, which difficulty can adjust dynamically. The first agent getting right answer of the math problem will have the authority to write data into blockchain.

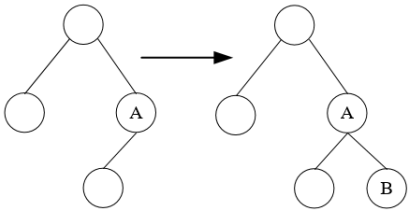

Figure 6. Transformation form of continuing the content

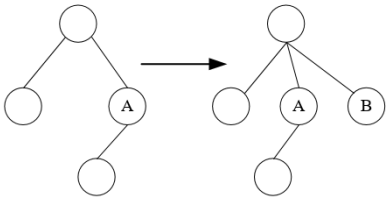

Figure 7 . Transformation form of rectifying the content

Rectifying and continuing frequently by many creators will lead nodes of task tree increase exponentially, but this system will not be faced with this problem. The creators of a task usually are limited in a small area, even some friends familiar with each other. So the other creator will not have authority to rectify or continue the task, but they can subscribe

the task and pay attention to the refresh information.

3.3. Storage System of Blockchain

As distributed database with linear structure, the timestamp mechanism of blockchain have great advantages in traceability and storage. For complex collaborative task tree, we design a high-performance mapping structure, connecting collaborate task tree and blockchain storage system together for efficient traceability.

According to the traditional linear chain structure of blockchain, each block have block body and block head. The hash value of block head is hash value of this block .The blocks connect each other via recording hash value of previous block. Because of the POW consensus mechanism, the hash value of the block is a particular one.

Each new block body store the data in a new node from collaborative task tree. We design another hash value in the block head, which is hash of block storing the father node data of this block. Figure 8 shows that the mapping the combination relationship of the blockchain storage and collaborate task tree.

$$f : A \rightarrow B \tag{2}$$

As shown in the (2), let *A* denote the last node of original block set with the tree structure and *B* denote the new node set with the chain structure. According to the mapping principle *f*, obviously, it is an one-to-one mapping, which do not lose the information of original structure.

In order to trace father node more efficient and successful, as shown in the Table 1, we need to maintain a key-value table. Address of each tree node is the key, and corresponding block hash of father block is the value in the table. After a tree node is generated and the data is stored into a block, system will insert an item of key-value pair in the table to update key-value table.

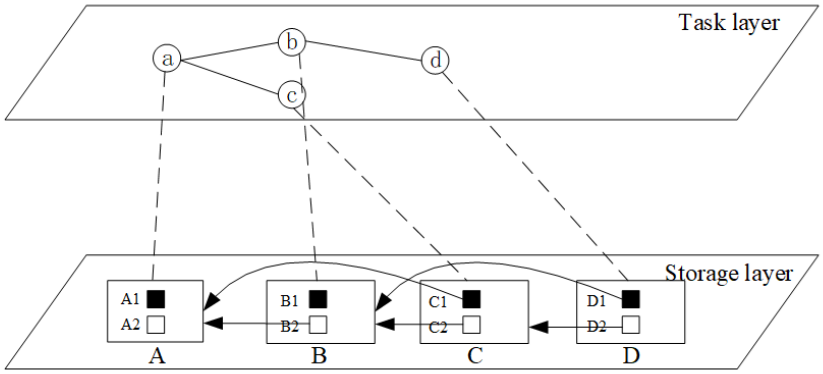

Figure 8. Traceability mechanism with two hash value

As shown in the Figure 8, each tree node is represented as lower case letters and each block is represented as higher case letters. There are two small item squares in each block, which represent two hash value pointing to two blocks. For instance, the black square *C1* represent hash value of block *A*, because *a* is the father node of *c* in the tree structure. And the white square *C2* represent hash value of block *B*, because block *B* is the previous block of block *C*, which is generated through Pow mechanism.

After a new tree node in the task layer is published, a new block will be generated soon according to the POW mechanism. The second hash value in the new block is pointing to previous block, Through finding the node and block address table, system can use address of father node of new tree node to get the first hash value pointing to a block which belongs to the same version of new block.

Table 1. Node And Block Address Table

NODE ADDRESS(KEY)	BLOCK ADDRESS(VALUE)
Adderse of node a	Address of block A
Address of node b	Address of block B
Address of node c	Address of block C
Address of node d	Address of block D

4. Traceability and distribution mechanism

4.1. Objective

As a collective creation management system, the main objective is to register creation data precisely and guarantee creators' acquisition. An accomplished creation might go trough rectification and conception for months even for years.

Blockchain technique has great advantages in the area of traceability such as food supply [18][19], medicine supply[20] and E-commerce products [21] and so forth. Our proposed collaborated creation system with blockchain technique aims for distributing creators' acquisition impartially.

4.2. Workflow

Traceability and distribution mechanism perform in the following steps

- Each block has its own timestamp when this block was generated, which can not been changed in the future. With timestamp, we can obtain the order of subtasks. In order to protect the intellectual property, the content of creation is only open to the creator in the same task and can not be duplicate, for fear that creation reveal to other platform. The only way to rectify the content is to fork a new brother node and generate a new block in the blockchain. And in the same creation, if two brother node has the similar content without fork operation, system will treat the later version as a plagiarism.

- There are many versions belonging to a creation. When we are interested in a certain version, we can trace the blockchain to get the whole content. As show in the structure introduction part, each block has two hash value recording. First hash value points to previous block in the blockchain structure, while the second hash value points to the block which is corresponding father node in the tree structure.

- Basic working principle of blockchain is that many distributed servers compete with each other to get writing priority to a new block, which lead to reliable storage. In order to prevent 51 percent attack, the blockchain servers consist of public servers and individual servers. Public servers, which is sustained by company, guarantee that system can implement at all times. Individual servers, which is sustained by individual company, take part in system implementation as personal regulator.

- After getting a certain version of creation, system will compute distribution for each individual creator. In this process, if a node is forked from another brother node, which means the new creator rectifies the old node, the old creator's effort should be taken into account.

4.3. Reward Evaluation Principles

If a version of task is ready to publish or export. We will use percentage proportion to represent the creators contribution. Several principles should be considered during traceability and distribution.

- First in First Serve Principle

We should attach more importance on the previous creators in that they work for this task for more time and make more contributions. Most of the time, previous parts of task set the foundation of the whole task. For instance, if collaborate creation is a book, the story line and people relationship are rely more on previous parts than the latter parts

- Plagiarism Punishment Principle
  Comparing the similarity of each sections in the task. If the similarity exceed the threshold, system will compare the timestamp of these sections. If some sections in the target version are deemed as a plagiarism, these creators will be considered as low weight in reward distribution. In the blockchain node submit procedure, system still have an plagiarism detection mechanism to cooperate with traceability part.

- Outstanding Encourage Principle
  In order to ignite the genius of creators, the outstanding section of tasks should be encourage. Every section of task will be ranked by volunteer crowd referees. The contribution proportion should multiply the outstanding rank value to take quality into consideration.

- Privacy Protection Principle
  To prevent creators' privacy, system should not let every collaborate creators know the reward from each other. One can only see the reward of himself. But in order to encourage creators to promote their ability, rank of their section is available to get.

- Modification Principle
  Good creators must have experienced repeated modification and reconsideration. Hence, to record the modification time of a section written by creators can generally justify the efforts that creators pay on the section. The modification time and editing time should both take into consideration.

5. Conclusion

In this paper, we propose a collective creation platform with blockchain technology. Blockchain has great advantages in reliable data storage and traceability. We make a mapping from tree structure of collaborate creation to chain structure of blockchain. For efficient traceability, we maintain a key-value table to improve the complexity of traceability algorithm .As an temporary work, the proposed system have following limitations:

- Due to the time which individual creator publish its creation subtask node is unpredictable, system need to adjust interval generation time between two adjacent block.

- If a malicious creators generate too many redundant version in the collective creation tree structure, the tree structure becomes so complicated, which will effect content storage and location. Make some restrictions to tree node for efficiency is the next objective to our system.

- In this paper, we propose the reward evaluation principles. These principles can be deemed as the basic rule of contribution distribution. But concrete and precise reward evaluating and traceability algorithm need to be completed in the future works.

In the future work, we will concentrate on deploying efficient scheduling algorithm between public and private server, and concentrate on setting node-generation rule to make current platform completely. Furthermore , in the traceability area, well-performance mechanism could be explored.

Acknowledgement

This work was supported by National Key Research and Development Project of China under Grant No. E0M2040101. We also thank all colleagues and graduate students who helped us for our system and experiments.

References

1. Nakamoto S, Bitcoin, a peer-to-peer electronic cash system (https://bitcoin.org/bitcoin.pdf, accessed September 2016)

2. Ethereum White Paper. A next-generation smart contract and decentralized application platform, (https://github.com/ethereum/wiki/wiki/WhitePaper, accessed November 12, 2015)
3. Yang Y, Wang J, Huang W, et al. “Crowd Intelligence-Based Interactive Creation Platform,” in Proceedings of 2019 IEEE 19th International Conference on Software Quality, Reliability and Security Companion (QRS-C), pp. 275-280, Sofia, Bulgaria, July 2019.
4. Gupta C, Farahat A, Hiruta T, et al. “Collaborative creation with customers for predictive maintenance solutions on hitachi iot platform”, Hitachi Review,vol.65, pp 403-409, 2016.
5. Swan M. Blockchain, “Blueprint for a New Economy”, O’Reilly Media, 2015.
6. Larimer D. Delegated proof-of-stake white paper, (http://www.bts.hk/dpos-baipishu.html, 2014)
7. Davidson S , De Filippi P , Potts J . Economics of Blockchain. Social Science Electronic Publishing.
8. S. Huh, S. Cho and S. Kim, “Managing IoT devices using blockchain platform,” in Proceedings of 2017 19th International Conference on Advanced Communication Technology (ICACT), pp. 464-467, Bongpyeong, Feb. 2017
9. Y. Zhang and J. Wen, “An IoT electric business model based on the protocol of bitcoin,” in Proceedings of 2015 18th International Conference on Intelligence in Next Generation Networks, pp. 184-191, Paris, 2015
10. Habib K , Torjusen A , Leister W . “Security Analysis of a Patient Monitoring System for the Internet of Things in eHealth,” in Proceedings of The Seventh International Conference on eHealth. 2015.
11. Sharples M, Domingue J. “The blockchain and kudos: A distributed system for educational record, reputation and reward”, in Proceedings of European conference on technology enhanced learning, pp 490-496, Cham, 2016.
12. R. Dennis and G. Owen, “Rep on the block: A next generation reputation system based on the blockchain”, in Proceedings of 2015 10th International Conference for Internet Technology and Secured Transactions (ICITST), London, 2015, pp. 131-138.
13. Axon L. Privacy-awareness in blockchain-based PKI. Cdt technical paper series, 2015.
14. G. Zyskind, O. Nathan and A. '. Pentland, “Decentralizing Privacy: Using Blockchain to Protect Personal Data,” in Proceedings of 2015 IEEE Security and Privacy Workshops, pp. 180-184, , San Jose,2015.
15. Michelucci P., Dickinson J.L. “The power of crowds: Combining humans and machines can help tackle increasingly hard problems”, Science, vol.351, pp. 32-33, 2016.
16. T. D. LaToza and A. v. d. Hoek, “A Vision of Crowd Development,” in Proceedings of 2015 IEEE/ACM 37th IEEE International Conference on Software Engineering, pp. 563-566, Florence, 2015,
17. G. Li, J. Wang, Y. Zheng and M. Franklin, “Crowdsourced Data Management: A Survey,” in Proceedings of 2017 IEEE 33rd International Conference on Data Engineering (ICDE), 2017, pp. 39-40, San Diego
18. Feng Tian, “A supply chain traceability system for food safety based on HACCP, blockchain & Internet of things,” in Proceedings of 2017 International Conference on Service Systems and Service Management, pp. 1-6, Dalian, 2017
19. Feng Tian, “An agri-food supply chain traceability system for China based on RFID & blockchain technology,” in Proceedings of 2016 13th International Conference on Service Systems and Service Management (ICSSSM), pp. 1-6, Kunming, 2016
20. Kumar R, Tripathi R. “Traceability of counterfeit medicine supply chain through Blockchain,” in Proceedings of 2019 11th International Conference on Communication Systems & Networks (COMSNETS), pp.568-570, Bengaluru, India, 2019.
21. Q. Lu and X. Xu, “Adaptable Blockchain-Based Systems: A Case Study for Product Traceability,” IEEE Software, vol.34, no. 6, pp. 21-27, November/December 2017.

Guoyang Pan is a master student at Institute of Automation, Chinses Academy of Sciences, China. He received his bachelor's degree from Northwestern Polytechnical University in 2019. His research interests include control theory and system engineering.

Yi Yang is a research associate at Institute of Automation, Chinses Academy of Sciences, China. His research interests include big data visualization and machine learning.

Guoqing Li is a research associate at Institute of Automation, Chinses Academy of Sciences, China. His research interests include data science.

Jian Wang is a researcher of Institute of Automation, Chinese Academy of Sciences, China. His research interests include deep learning and control theory.

Weixing Huang is an associate researcher at Institute of Automation, Chinses Academy of Sciences, China. Her research

interests include cultural and technological integration.