Review on Blockchain-based Cloud Task Scheduling

Nora Almezeini,

King Saud University, Management Information Systems Dept., Saudi Arabia

Summary
Cloud computing has been an important and popular distributed computing model that supports on demand services. It offers its services to internet users through service providers on pay-per-use basis. Using resources efficiently by reducing execution time and cost and increasing profit is the main goal of cloud service provider. Moreover, security is an important criteria in cloud computing. Blockchain has been recently a promising technology for the security improvement in cloud computing especially in scheduling. This paper reviews the cloud task scheduling models that utilized blockchain technology in order to improve its efficiency and security. Moreover, it shows the importance of using blockchain in task scheduling for future researches.

Key words:
Cloud Computing; Blockchain; task scheduling; security

1. Introduction

Cloud computing has grown rapidly and gained considerable attention because it provides flexibility and scalability to organizations. Cloud computing is a large scale distributed system which provides a pool of computing resources to cloud consumers through the internet. There are many cloud providers which run on cloud computing environment such as Amazon, Google Engine, IBM, and Microsoft. They provide services and resources to users on the basis of pay per use at anytime from anywhere[1].
Many of the scientific researches on cloud computing had focused on the efficient performance of task scheduling. Task scheduling concerns about mapping tasks to appropriate resources, efficiently. Finding an optimal solution in cloud computing is considered an NP-complete problem. Each scheduling algorithm is based on one or more strategy. The most important strategies or objectives commonly used are time, cost, energy, quality of service (QoS), and fault tolerance [2].
Blockchain technology was firstly developed to produce the cryptocurrency. However, it has been utilized for several applications and became a promising technology because of its security features [3]. When using blockchain, data can be stored in distributed databases instead of using of storing all data in a central data center. This will improve the security of the whole cloud system, because it will prevent the damages from attacks on such databases easily [4].
There are some researches already discussed the utilization of blockchain and cloud computing in different areas [5], such as security [6], decentralized applications [7], virtual machine migration [8], and resource scheduling [9]. Also, Blockchain-as-a-service concept has been presented, which combines cloud computing and blockchain and allows users to benefit from cloud-based solutions to build, host, and manage their own blockchain applications on the blockchain [10]. AWS Blockchain and Azure Blockchain are examples of BaaS [5].
The rest of the paper is organized as follows. Section II discusses the background of cloud computing and blockchain. Then details the current state of blockchain-based cloud task scheduling in section III. Finally, conclusions and future work are presented in section IV.

2. Background

2.1 Cloud Computing

Cloud computing is a distributed system that provides services to Internet users through service providers such as Amazon, Google, Apple, Microsoft, and others. The National Institute of Standards and Technology (NIST) has defined cloud computing as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction" [11].
Cloud computing offers three main delivery models which are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). In Software as a Service (SaaS), Applications and access management tools are provided to users. Platform as a Service (PaaS) provides tools such as operating systems, databases, and network so consumers can install and develop their own software and applications. Infrastructure as a Service (IaaS) provides access to physical devices such as hardware and network so consumers can install and develop their own operating systems and applications [1].
Clouds in cloud computing are of several types based on the scalability and pooling up of the resources. Types are public, private, community, and hybrid clouds. Public clouds are available to the general public in a pay-as-you-go manner and they are owned by the cloud provider. Private clouds are operated only for a business or an organization and they are controlled by that organization or a third party. In

Manuscript received October 5, 2020
Manuscript revised October 20, 2020
https://doi.org/10.22937/IJCSNS.2020.20.10.18

community clouds, several organizations share the infrastructure of the cloud to support certain community that has common concerns. Hybrid clouds are combination of public, private, or community clouds [12]. Figure 1 summarizes the components of cloud computing.

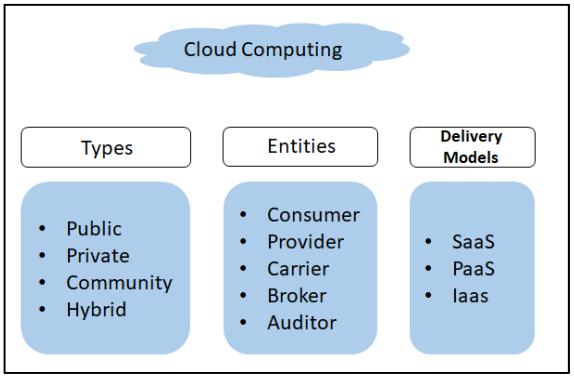

Fig. 1 Cloud Computing Architecture.

The concept of scheduling in cloud computing refers to the technique of mapping a set of tasks to a set of virtual machines (VMs) or allocating VMs to run on the available resources in order to obtain users' demands. The main goal of using scheduling techniques in cloud environment is to enhance system throughput and load balance, maximize the resource utilization, save energy, reduce costs, and minimize the total processing time. Therefore, the scheduler should consider the virtualized resources and users' required constraints to get efficient matching between jobs and resources. Each scheduling technique should be based on one or more strategies. The most important strategies or objectives commonly that are used, are time, cost, energy, QoS, and fault tolerance [1].

2.2 Blockchain

Blockchain was firstly introduced by Satoshi Nakamoto in 2008 [13], as main part of Bitcoin for recording Bitcoin transactions. Blockchain can be considered as a distributed ledger which records all data and transactions in a blockchain permanently and verifiably across a peer-to-peer network [10].
Blockchain is a sequence of blocks that contains the complete transaction log. It is acting as a public book and it is maintained by multiple nodes in the network. All transactions in the blockchain are recorded in the public ledger permanently and in a verifiable manner, so each node has an identical copy of this ledger. Each block in the blockchain contains the following as shown in Figure 2:

- A logical sequence of transactions, which are permanent, transparent, and unchangeable records.
- A timestamp.
- Unique hash value of the previous block (the parent), so any changes to the block will immediately change the hash value.
- A nonce, which is a random number to verify the hash value.

This concept ensures the integrity of the previous blocks till the first block which is called the genesis block [5][10].

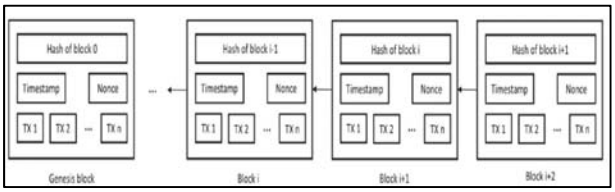

Fig. 2 Blocks Components in Blockchain [5]

Blockchain technology has been utilized for several applications with further development and different goals, such as Ethereum Blockchain and Hyperledger Fabric blockchain solutions [5]. All of them have the following common elements:

- Replicated ledger: all nodes in the blockchain network has a replicated copy of transactions history which is written in a hyper ledger. And new transactions are packaged into a block and then is append-only with immutable past.
- Peer-to-Peer network: all nodes are connected via a peer-to-peer network and share a public ledger without a centralized control of a third party. [2in1]
- Consensus: all nodes in the blockchain should achieve to a consensus on the validity and the order of transactions in the blocks before inserting the blocks into the chain.
- Cryptography: it is the basis of blockchain system security. The integrity and authenticity of transactions are supported by digital signature and the privacy of transactions is supported by asymmetric cryptosystem.

On the other hand, blockchain technology has some drawbacks. It causes a waste of storage since it is immutable and append-only so its storage space is increasing and is distributed among the nodes in the network. Moreover, transaction throughput is an important issue which is measured by transactions per second. Also, there are some other issues such as network congestion, block size, and synchronization mechanism which have been studied in many researches [14][15][16][17].

3. Blockchain based Task Scheduling in Cloud Computing

Scheduling in cloud computing is a NP-complete optimization problem. It aims to map tasks efficiently to a set of physical and virtual machines in the cloud system. It helps to improve the efficiency of energy by enhancing various parameters such as makespan, execution time, total wait time, total completion time, and QoS. Many task scheduling algorithms are developed to improve these parameters [1].

Moreover, security is an important criterion in task scheduling in cloud computing. Some tasks may require data protection and privacy policies and need to be executed in in special protected machines. Also, it is important to protect cloud system against external attacks to avoid the infection of the generated schedule during its execution. Many publications proposed security models in cloud task scheduling based on trust level and security demand parameters such as [18][19][20]. However, these models are theoretical and not applicable in real life because it cannot be easily determined and measured [4].

Recently, blockchain has been the promising technology for the security improvement in cloud computing especially in scheduling. However, the integration of the blockchain architecture and scheduling algorithms to improve security remains an open research problem.

In [9], the author proposed a trusted distributed audit method for cloud task scheduling which combines blockchain with task scheduling. It protects and stores the data of cloud task scheduling in the cloud databases in order to improve the confidentiality and availability of data and decrease the risk of attacks. The performance evaluation of the proposed system was acceptable.

In [21], the author used the smart contracts to store the data in distributed databases in the blocks, so the tasks are assigned to datacenters that have lowest load in the blocks. The author in [22] focused on testing blockchain network using 'Shortest Job First' scheduling algorithm for minimizing the response waiting time and allocating the proper data servers. The results showed high inability to process the data, which enhances the security of the cloud.

Moreover, the author in [23] utilized blockchain for task scheduling to reduce energy consumption. They concluded that blockchain is more reliable and has many security features for storing data. However, it would consume time and energy when large number of tasks are stored in the blockchain network. Also, it would be difficult to create new blocks. Therefore, blockchain is more feasible for security purposes.

In general, block chain is a new type of distributed computing architecture based on cryptography, peer-to-peer network communication, consensus algorithm, smart contract and so on. Since data and transactions are not under the control of a third party, the characteristics of data are not easy to manipulate with, not easy to fake, traceable and auditable. These characteristics can prove that the blockchain technology can effectively ensure the reliability and security of data stored by cloud task scheduling [9].

4. Conclusion

It is obvious that using cloud computing and blockchain together has been very beneficial for several areas especially for security and preventing attacks. This paper presents that developing task scheduling based on blockchain in cloud computing is still in the early stages and remains an open research problem.

This paper encourages researchers to develop more blockchain based task scheduling models and examine them to augment security and integrity of data over the cloud in order to propose a more stable and secure cloud system solution.

Acknowledgments

This research was supported by the Deanship of Scientific Research, King Saud University, Saudi Arabia.

References

[1] N. Almezeini and A. Hafez, "Review on Scheduling in Cloud Computing," Int. J. Comput. Sci. Netw. Secur., vol. 18, no. 2, pp. 108–111, 2018.

[2] N. Almezeini and A. Hafez, "Task Scheduling in Cloud Computing using Lion Optimization Algorithm," Int. J. Adv. Comput. Sci. Appl., vol. 8, no. 11, pp. 77–83, 2017.

[3] M. Nofer, P. Gomber, O. Hinz, and D. Schiereck, "Blockchain," Bus. Inf. Syst. Eng., vol. 59, no. 3, pp. 183–187, 2017, doi: 10.1007/s12599-017-0467-3.

[4] A. Wilczyński and J. Kołodziej, "Modelling and simulation of security-aware task scheduling in cloud computing based on Blockchain technology," Simul. Model. Pract. Theory, vol. 99, p. 102038, 2020, doi: https://doi.org/10.1016/j.simpat.2019.102038.

[5] E. F. Coutinho, D. E. Paulo, A. W. Abreu, and I. M. B. Carla, "Towards Cloud Computing and Blockchain Integrated Applications," in 2020 IEEE International Conference on Software Architecture Companion (ICSA-C), 2020, pp. 139–142, doi: 10.1109/ICSA-C50368.2020.00033.

[6] C. Esposito, A. De Santis, G. Tortora, H. Chang, and K. R. Choo, "Blockchain: A Panacea for Healthcare Cloud-Based Data Security and Privacy?," IEEE Cloud Comput., vol. 5, no. 1, pp. 31–37, 2018, doi: 10.1109/MCC.2018.011791712.

[7] R. B. Uriarte and R. DeNicola, "Blockchain-Based Decentralized Cloud/Fog Solutions: Challenges, Opportunities, and Standards," IEEE Commun. Stand. Mag., vol. 2, no. 3, pp. 22–28, 2018, doi: 10.1109/MCOMSTD.2018.1800020.

[8] T. Uchibayashi, B. O. Apduhan, N. Shiratori, T. Suganuma, and M. Hiji, "Policy Management Technique Using Blockchain for Cloud VM Migration," in 2019 IEEE Intl

Conf on Dependable, Autonomic and Secure Computing, Intl Conf on Pervasive Intelligence and Computing, Intl Conf on Cloud and Big Data Computing, Intl Conf on Cyber Science and Technology Congress (DASC/PiCom/CBDCom/CyberSciTech), 2019, pp. 360–362, doi: 10.1109/DASC/PiCom/CBDCom/CyberSciTech.2019.00073.

[9] H. Zhu, Y. Wang, X. Hei, W. Ji, and L. Zhang, "A Blockchain-Based Decentralized Cloud Resource Scheduling Architecture," in 2018 International Conference on Networking and Network Applications (NaNA), 2018, pp. 324–329, doi: 10.1109/NANA.2018.8648712.

[10] W. Zheng, Z. Zheng, X. Chen, K. Dai, P. Li, and R. Chen, "NutBaaS: A Blockchain-as-a-Service Platform," IEEE Access, vol. 7, pp. 134422–134433, 2019, doi: 10.1109/ACCESS.2019.2941905.

[11] P. Mell and T. Grance, "The NIST definition of cloud computing," 2011.

[12] N. Antonopoulos and L. Gillam, Cloud Computing Principles, Systems and Applications, 2nd ed. Springer International Publishing, 2017.

[13] S. Nakamoto, "Bitcoin: A peer-to-peer electronic cash system," Manubot, 2019.

[14] J. Yli-Huumo, D. Ko, S. Choi, S. Park, and K. Smolander, "Where Is Current Research on Blockchain Technology?—A Systematic Review," PLoS One, vol. 11, no. 10, p. e0163477, Oct. 2016, [Online]. Available: https://doi.org/10.1371/journal.pone.0163477.

[15] J. Kwon, "Tendermint: Consensus without mining," Draft v. 0.6, fall, vol. 1, no. 11, 2014.

[16] A. Kosba, A. Miller, E. Shi, Z. Wen, and C. Papamanthou, "Hawk: The Blockchain Model of Cryptography and Privacy-Preserving Smart Contracts," in 2016 IEEE Symposium on Security and Privacy (SP), 2016, pp. 839–858, doi: 10.1109/SP.2016.55.

[17] I. Eyal, A. E. Gencer, E. G. Sirer, and R. Van Renesse, "Bitcoin-ng: A scalable blockchain protocol," in 13th {USENIX} symposium on networked systems design and implementation ({NSDI} 16), 2016, pp. 45–59.

[18] J. Kołodziej and F. Xhafa, "Integration of task abortion and security requirements in GA-based meta-heuristics for independent batch grid scheduling," Comput. Math. with Appl., vol. 63, no. 2, pp. 350–364, 2012, doi: https://doi.org/10.1016/j.camwa.2011.07.038.

[19] S. Song, K. Hwang, and Y.-K. Kwok, "Trusted Grid Computing with Security Binding and Trust Integration," J. Grid Comput., vol. 3, no. 1, pp. 53–73, 2005, doi: 10.1007/s10723-005-5465-x.

[20] S. Song, K. Hwang, and Y.-K. Kwok, "Risk-resilient heuristics and genetic algorithms for security-assured grid job scheduling," IEEE Trans. Comput., vol. 55, no. 6, pp. 703–719, 2006, doi: 10.1109/TC.2006.89.

[21] S. Wang, L. Ouyang, Y. Yuan, X. Ni, X. Han, and F. Wang, "Blockchain-Enabled Smart Contracts: Architecture, Applications, and Future Trends," IEEE Trans. Syst. Man, Cybern. Syst., vol. 49, no. 11, pp. 2266–2277, 2019, doi: 10.1109/TSMC.2019.2895123.

[22] H. Jha, S. Chowdhury, and G. Ramya, "Survey on various Scheduling Algorithms," Imp. J. Interdiscip. Res., vol. 3, 2017.

[23] F. A. Lokhandwala, "A Heuristic Approach to Improve Task Scheduling in Cloud Computing using Blockchain technology." Dublin, National College of Ireland, 2018.