Global Journal of Computer Science and Technology: E
Network, Web & Security
Volume 22 Issue 2 Version 1.0 Year 2022
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Blockchain and Smart Contracts as Complex Self-Organizing Frameworks: Theoretical Perspective

By Neyole Misko, Dr. Rono Kipronoh & Dr. Muchelule Yusuf

Abstract- Blockchain offers unprecedented opportunities for innovation in financial transactions with a whole new world of opportunities for banking, lending, insurance, and money transfers. Through its algorithms, digital security by decentralization, form smart contracts. Smart contracts allow the performance of credible transactions without third parties, the transactions premised by trackable and irreversible processes are superior to traditional contract law and greatly reduce other transaction costs associated with contracting. Globally, enterprises are undergoing a major transformation towards smart businesses that use intelligent systems integrated into planning for their daily routine. Blockchain technology and smart contacts termed disruptive technologies provide innovative solutions that cannot be ignored due to their inherent complexities. Regarded as complex systems, there is a need to have a theoretical view to understanding the hidden order to the evolution of these systems to bring out traits that are common and have a combination of independent actors behaving as a single unit responding and adapting to their existent setting, as self-organizing systems.

Keywords: blockchain, smart contracts, complex systems, self-organizing frameworks, theoretical perspective.

GJCST-E Classification: DDC Code: 332.178 LCC Code: HG1710

Blockchain and Smart Contracts as Complex Self-Organizing Frameworks: Theoretical Perspective

Neyole Misko [α], Dr. Rono Kipronoh[σ] & Dr. Muchelule Yusuf [ρ]

Abstract- Blockchain offers unprecedented opportunities for innovation in financial transactions with a whole new world of opportunities for banking, lending, insurance, and money transfers. Through its algorithms, digital security by decentralization, form smart contracts. Smart contracts allow the performance of credible transactions without third parties, the transactions premised by trackable and irreversible processes are superior to traditional contract law and greatly reduce other transaction costs associated with contracting. Globally, enterprises are undergoing a major transformation towards smart businesses that use intelligent systems integrated into planning for their daily routine. Blockchain technology and smart contacts termed disruptive technologies provide innovative solutions that cannot be ignored due to their inherent complexities. Regarded as complex systems, there is a need to have a theoretical view to understanding the hidden order to the evolution of these systems to bring out traits that are common and have a combination of independent actors behaving as a single unit responding and adapting to their existent setting, as self-organizing systems. This study significantly plays a unique role in contemporary science by explaining how blockchain and smart contracts unify run as nonlinearity complex system that adapts to their environment to bring about consistency hence their applicability.

Keywords: blockchain, smart contracts, complex systems, self-organizing frameworks, theoretical perspective.

I. Introduction

Blockchain [1] is essentially a distributed database of records in the form of a public ledger that holds transactions and digital events that have been executed, verified by consensus, and shared among participating parties [2]. Defined as a foundation of Bitcoin [3], it ensures that every transaction is set public, consensus verified, and permanently stored in chains of blocks simply put Blockchain creating automated trust through the decentralized ledger that is distributed to all participants in the blockchain.

These underlined technology-entrenched undertakings have demonstrated through the power of the trust, consensus mechanisms, and deliberate veneration of the social contract that it is possible to use the internet to make a decentralized value-transfer system [4] and since it is a chain, the technology is easy to trace back an event shared across geographical boundaries. These processes are essentially unregimented, open, and rather not dominated by a tightly organized social or economic system.

The advent of blockchain has led to the development of important technological drivers for the world economy such as the concept of the smart contract. In a blockchain context, smart contracts mean transactions that go beyond simple buy and sell currency transactions, that have more extensive instructions embedded into them [5]. Technically, a contract is a set of IFs and THEN statements that give conditions and actions. Swan (2015), further indicates that much as the contracts feature the same kind of agreement to act or not act, they remove the need for one type of trust between parties as the smart contract is both defined and executed by the code automatically without discretion making a contract autonomy, self-sufficiency and decentralization.

Smart contracts in turn enable a decentralized application that accomplishes more than a transfer of value [6]. Its efficient automation of decentralized application can therefore be transitioned into solving real-world problems such as in managing real-time secure health records in medical facilities, in agriculture to provide experts and farmers greater interaction and sharing of data that affect land produce and in government ministries such as the lands ministry to update and manage lands record.

The smart contract has been established as a program deployed within a distributed network that can acquire outside information and update the internal state automatically. With the emergence of Ethereum as a built-in Turing-complete scripting language, the popularity and use of smart contract has been rising rapidly [7]. Currently, smart contracts are mainly embedded and used in blockchain distributed ledgers utilizing Ethereum as a platform [8].

II. Applications And use Of The Technology

Globally, many enterprises are undergoing a major evolution and transformation towards smart businesses where intelligent systems are being

Authore α σ ρ: e-mails: jmisiko@umma.ac.ke, ronohkipronoh@gmail.com, mucheluly@gmail.com, ymuchelule@umma.ac.ke

developed alongside a plethora of smart programs, services, and transactions integrated into planning for their daily routine. Startup firms and major enterprises alike are now developing smart contract solutions for an assortment of markets, alleging to offer a digital bypass around traditional mechanisms. The concept is to make smart contracts offer a superior solution to the challenges and limitations businesses face. The potential and the limitations of smart contracts have been and are being tested by offering novel possibilities to significantly alter traditional methods of doing thing spositively.

Karamitsos et.al (2018) presented a paper with an overview of Blockchain technology as a disruptive technology for the real estate industry. This study was designed to determine the effect of the smart contract with the various components for the implementation specifically to Real Estate development with the adoption of Blockchain to optimize the current processes. The paper observed among others the following recompenses of using smart contracts and blockchain technology in real estate: - different parties easy to modify databases in the real estate ecosystem, the advantage of disintermediation, and transactions advantage among other [9].

Smart contracts[10] have found applications in two main aspects: electronic monetary transactions and applications for storing information [11]. Bogner et al. [2016] developed a smart contract application aiming to rent devices. The food supply field has applied smart contracts to achieve food trade [12], [13] since smart contracts decrease the costs of traders on the food supply chain while providing a decentralized, accountable and transparent architecture based on blockchain technology.

Al-Bassam [2017] built a system for identity management, and organizational process for identifying, authenticating, and authorizing individuals' people to have access to applications, systems, or networks by associating user rights and restrictions with established identities. Shangping et al. (2019) proposed a product traceability system based on blockchain technology in which all product transferring histories would be perpetually recorded in the unchangeable ledger by using smart contracts, and the process of product registration, transferring and tracking is realized through the collaboration of smart contracts.

Through the supply chain process, customers would participate in the process as nodes to maintain information flows. The system described by decentralized characteristics would significantly reduce issues of privately tampering with data within enterprises and the system would have an event response mechanism to verify the identity of both parties of the transaction and by verifying the signature contained in the event to determine whether the event is valid. All events can be listened to and permanently stored in the blockchain in the form of a log. The results of the security analysis show that the system would be characterized by data accessibility, tamper-proofing, and resistance to man-in-the-middle attacks [14].

Hasan & Salah (2018) presented a blockchain-based solution and framework for the PoD of digital assets in which the framework was generic enough that it could be used to orchestrate and govern the sale and delivery of any digital asset and content including streaming video and audio. Based on the novel system, all transactions and interactions for the sale and download of digital items were to be controlled by Ethereum smart contracts. The demonstration showed that implementing smart contract code is safe and free of known exploitable security vulnerabilities and bugs. The solution also addressed some key security requirements such as security against popular attacks such as MITM and replay attacks [15].

Salah et al. (2019) proposed a framework leveraging Ethereum blockchain and smart contracts to trace, track, and perform business transactions by removing intermediaries for soybean traceability across the agricultural supply chain. The novel presentation presented details and aspects related to the system architecture, design, entity-relation diagram, interactions, sequence diagrams, and implementation algorithms. They showed that blockchain as a disruptive technology could provide an innovative solution for product traceability in agriculture and food supply chains. That could leverage the supply chain process to efficiently perform business transactions for soybean tracking and traceability across the agricultural supply chain.

III. Complex Self-Organizing Frameworks

Complexity theory premises that there is a hidden order to the evolution of complex systems, whether that system is a national economy, an ecosystem, an organization, or a production line. The Protagonists of the theory believe that certain traits are common to most complex systems where the systems are a combination of many independent actors behaving as a single unit and responding to their existent setting. To help understand the use of the theory in the modeling and analyzing complex systems, some frameworks contribute as core sets of commonality generic frameworks to understand the theory. They include: - Self-organizing, the adaptive system, the network theory, and nonlinear system theory.

a) Self-Organizing and Emergence Theory

Self-organization theory describes characteristic relationships in emergent systems complex systems as created by feedback mechanisms that either amplify an effect to give positive feedback or dampen an effect to give negative feedback [16]. By definition, a complex system is a system composed of a large number of different interacting elements [17] it is therefore composed of many parts without centralized control. Emergence, described as a key concept in complexity science is the growth and evolution of more complex forms through simple rules. It, therefore, refers to how new levels of an organization are formed as parts are assembled.

Models of self-organization theory draw upon information theories to help understand the organization in terms of information and entropy. The theory also draws upon ideas of physics surrounding synchronization and pattern formation. Researchers try to model complex systems by capturing the local rules and using complex computational tools such as solidity for Ethereum framework or agent-based modeling to try and simulate the process through which order emerges out of initially homogenous or disordered states.

b) Complex Adaptive System

According to Sammut-Bonnici (2015), complex adaptive systems (CAS) consist of diverse components that are interdependent, act as a unified whole, and can learn from experience and adapt to change in the environment. Consequently, adaptive systems are classical examples of complex systems. They consist of many parts acting and reacting to each other's behavior. They are highly dynamic and developed through an evolutionary-like process the central issues being that of the process of adaptation and evolution.

Adaptation forms a central part of cybernetics that contributes to ideas surrounding control systems and how systems regulate themselves in their environment to maintain themselves (homeostasis). The key issue here is the dynamic surrounding cooperation and competition that form as adaptive agents interact and try to pursue their goals collectively. When ideas of adaptation are generalized to a whole population of agents and take place over a series of life cycles it can be termed evolution. This is supported by other theories such as evolution game theory, replicator equation, fitness landscapes, and genetic algorithm among others.

c) Network Theory

Network theory can be explained as the study of graphs as a representation of either symmetric relations or asymmetric relations between discrete objects, for computer science and network science, network theory is a part of graph theory characterized by nodes and edges that have attributes [18]. All complex systems can be modeled and analyzed as networks.

Network theory is a formal mathematical language but it has proven a very practical tool for analysis and found widespread application in many areas. Network theory has become an important study for complex systems, especially with the advent of information technology. Network theory is driven less by models and equations but more by real-time dense datasets, meaning we no longer stare at the models but are accessible to visualization to get us a much richer intuitive real source of exactly what the complex systems are like. Areas of contribution here are mathematics (graph theory) and computer science [19].

d) Nonlinear System and Chaos Theory

Non-linearity is an inherent feature and major theme that crosses all areas of complex systems. Chaos theory which is the study of non-linear dynamical systems was one of the major challenges to the Newtonian paradigm that was accepted into the mainstream of scientific knowledge [20] [21]. By definition, Chaos theory is a part of mathematics that looks at certain systems that are very sensitive in that any small change may make the system behave completely differently [22]. The modern scientific framework is based upon linear systems theory and this places significant constraints upon it.

Linear systems theory is dependent upon the concept of a system having an equilibrium [23]. All linear systems work as an approximation the fact is that many of the phenomena are nonlinear processes of change that happen far from equilibrium and are governed by dynamics of feedback loops and not linear equations. Trying to model complex systems by use of the traditional linear system is not effective hence areas of nonlinear systems and dynamics are a major part of complexity theory borrowed largely from physics, mathematics, and equilibrium processes from chemistry [24] [25].

IV. Conclusion

The Newtonian paradigm is a clockwork universe concept, a scientific model that supports science characterized by a materialistic and atomistic vision of sequestered inert objects interacting in a linear cause and effect fashion- the linear systems theory. This gives a concept of the universe that is analog to a system that is orderly, coherent, and predictable. Linear systems theory deals with relatively simple systems, systems that have a finite amount of independent, homogeneous elements interacting in a well-defined fashion with a relatively low level of connectivity. In its essence, linear systems theory fundamentally describes closed systems at or near equilibrium.

The context and significance of complexity theory are that it plays a unique role in contemporary science. Defined as an emerging post- Newtonian paradigm, it is a unifying point of view that views nonlinear complex systems running and adapting to their environment to bring about consistency. the current

Global Journal of Computer Science and Technology (E) Volume XXII Issue II Version I Year 2022

society is surrounded by complex nonlinear systems that are well described by nonlinear theories such as the complexity theory. The theory, therefore, borrows support from the four models namely Network Theory, Complex Adaptive Theory, Nonlinear Systems Theory, and Self Organization Theory to try and explain complex systems such as the blockchain Ethereum platform for smart contracts and their applicability.

Acknowledgements

I acknowledge the support I was given by the UMMA University Computer science department for their academic critique and professionalism that guided my writing of the paper. Am fully indebted to them.

References Références Referencias

1. S. Nakamoto, "Bitcoin: A Peer-to-Peer Electronic Cash System," pp. 1-9, 2008.
2. M. Crosby, P. Pattanayak, S. Verma and V. Kalyanara, "Blockchain technology: Beyond bitcoin," Applied Innovation, pp. 6-19, 2016.
3. Z. Zibin, X. Shaoan, D. Hongning, C. Xiangping, and W. Huaimin, "An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends," IEEE 6th International Congress on Big Data, pp. 557-566, 2017.
4. G. Wood, "Ethereum: A secure decentralized generalized transaction ledger.," Ethereum project yellow paper, pp. 1-32, 2014.
5. M. Swan, Blockchain: Blueprint for a new economy, USA: O'Reilly Media, Inc, 2015.
6. H. Yining, L. Madhusanka, A. Manzoor and K. Thilakarathna, "Blockchain-based Smart Contracts - Applications and Challenges," University of New South Wales, Aruna Seneviratne, 2019.
7. F. Tianyu, Y. Xiao, C. Yueting and L. Yi, "Smart contract model for complex reality transaction," International Journal of Crowd Science, pp. 184 - 197, 2019.
8. V. Buterin, "Ethereum: a next-generation smart contract and decentralized application platform," 2014. [Online]. Available: https://www.weusecoins.com/assets/pdf/library/Ethereum_white_paper-a_next_generation_smart_contract_and_decentralized_application_platform-vitalik-buterin.pdf.
9. I. Karamitsos, M. Papadaki and N. B. Al Barghuthi, "Design of the Blockchain Smart Contract: A Use Case for Real Estate," Journal of Information Security, pp. 177-190, 2018.
10. B. M and P. L, "An empirical analysis of smart contracts: platforms, applications, and design patterns," ' in Proc. Int. Conf. Financial Cryptographic Data Security, p. 494–509, 2017.
11. M. Dianhui, W. Fan, W. Yale, and H. Zhihao, "Visual and User-Defined Smart Contract Designing System Based on Automatic Coding," IEEE, pp. 73131 - 73144, 2019.
12. G. Peters, E. Panayi, and A. Chapelle, Trends in Crypto-Currencies and Blockchain Technologies: A Monetary Theory and Regulation Perspective vol.3, New York, NY, USA:: Social Science Electronic Publishing, 2015.
13. R. Adams, G. Parry, P. Godsiff and P. Ward, "The future of money and further applications of the blockchain," International journal for Strategic Change, pp. 417 - 422, 2017.
14. W. Shangping, L. Dongyi, Z. Yaling and C. Juanjuan, "Smart Contract-Based Product Traceability System in the Supply Chain Scenario," IEEE, pp. 115122 - 115134, 2019.
15. H. R. Hasan and K. Salah, "Proof of Delivery of Digital Assets Using Blockchain and Smart Contracts," IEEE, pp. 65439 - 65449, 2018.
16. ESPA, "Emergence and Self-Organization," 5 October 2019. [Online]. Available: http://www.complexity.soton.ac.uk/theory/_Emergence_and_Self-Organization.php.
17. G. Weisbuch, Complex systems dynamics, Boca Raton London New York: CRC Press Taylor &Francis Group, 2018.
18. E. Estrada and P. A. Knight, A First Course in Network Theory, London: OXFORD University Press, 2015.
19. J. Baez, Network Theory, USA: University of Califonia, 2015.
20. W. J. Rugh, Nonlinear System Theory The Volterra/Wiener Approach, USA: The Johns Hopkins, 2002.
21. J. P. Noël and G. Kerschen, "Nonlinear system identification in structural dynamics: 10 more years of progress," Mechanical Systems and Signal Processing, pp. 2 - 35, 2016.
22. A. T. Azar and S. Vaidyanathan, Advances in Chaos Theory and Intelligent Control, Switzerland: Springer International Publishers, 2016.
23. J. P. Hespanha, Linear System Theory 2nd. Edition, New Jersey: Princeton University Press, 2017.
24. H. Ozbay, Introduction to feedback control theory, Boca Raton London New York Washington, D.C: CRC Press, 2000.
25. J. M. Epstein, Nonlinear Dynamics,Ma them atical, Biology, and Social Science, Boca Raion London Mew York: CRC Press Taylor & Francis Group, 2018.