Ensuring Data Security in the Peer-to-Peer Economic System of the DAO

Sergiy Obushnyi[1], Denis Virovets[1], Hennadii Hulak[1], Artem Platonenko[1], and Roman Kyrychok[1]

[1] *Borys Grinchenko Kyiv University, 18/2 Bulvarno-Kudriavska str., Kyiv, 04053, Ukraine*

Abstract

The article raises the problem of using in DAO, has a high level of interaction with participants and participants, makes decisions, including using it with the help of autonomous economic agents. The article also provides a general description of the risks and issues that need to be addressed for the trusted use of peer-to-peer data in a DAO. In addition to this presented DAO decision making model, which can be used for investment, commercial and administrative models for DAOs.

Keywords

P2P economy, cryptoeconomics, decentralized autonomous organization, DAO, blockchain, Big Data, data management, autonomous agents.

1. Introduction

Modern digital innovation technologies, such as P2P networks, blockchain, artificial intelligence and social networks, combined with methods of data collection and processing, being partly or completely decentralized, represent new opportunities at several levels of economic relations. In the context of digitalization of the economy, new forms of cooperation as Decentralized autonomous organizations (hereinafter - DAO) are becoming relevant with a simultaneous reduction of the role of intermediaries. Increasing the number of electronic communication devices and sensors actually lead to the creation of new forms of cooperation, where borders and distances will not be an obstacle to combine human efforts and resources, with increasing information exchange and strengthening data quality requirements. Decentralized autonomous organizations as effective substitute for the institution of economic mediation and traditional forms of commercial cooperation, represent a new form of data collection and management mechanism with the purpose to organize human and digital resources for digital or real product production.

Despite the wide coverage of the possibilities of working with DAO, the issue of building decision-making models in DAO has been little studied. Similar to the strategic and tactical challenges faced by traditional corporations, the digital nature of data makes it imperative to take data security into account when making decisions. At the same time, given the adaptability of the data, today there are practically no peer-to-peer databases available for free and safe use in DAOs. Recent developments in the field of blockchain have shown the possibility of using such databases from different peer-to-peer systems, subject to certain conditions for data adaptation. In addition, to date, systems for safe and relatively inexpensive data storage and transmission have been tested, which opens up new opportunities for using data in DAO.

In this article, we describe the potential for effective big data analytics through enhanced security and privacy, as well as an effective management system of DAO, fully protected by blockchain, and joint investment and control of digital assets through a DAO as a new form of cooperation.

CPITS-II-2021: Cybersecurity Providing in Information and Telecommunication Systems, October 26, 2021, Kyiv, Ukraine
EMAIL: s.obushnyi@kubg.edu.ua (S. Obushnyi); seito@ukr.net (D. Virovets); h.hulak@kubg.edu.ua (H. Hulak); a.platonenko@kubg.edu.ua (A. Platonenko); r.kyrychok@kubg.edu.ua (R. Kyrychok)
ORCID: 0000-0001-6936-955X (S. Obushnyi); 0000-0003-4934-8377 (D. Virovets); 0000-0001-9131-9233 (H. Hulak); 0000-0002-2962-5667 (A. Platonenko); 0000-0002-9919-9691 (R. Kyrychok)

We believe that competent structuring of the process of managing and storing data will create new forms of digital cooperation models for the redistribution of digital assets and creation of products.

2. Actuality of the Problem

The problem of using data in peer-to-peer systems and its application with decision making models began to be investigated from the moment of the active development of cryptocurrencies and the distribution of digital products on the blockchain, and has been presented in many articles since 2013. In the context of decentralized cooperation, where it is permissible to use data in different DAO nodes, it is necessary to take into account the structure and type of data, the conditions of their existence and characteristics in order to effectively use them.

Both current and new projects in the digital economy, based on real or digital business, in their development, will be characterized by application of certain financial or technical information. The incoming data in real time will characterize the state of the blocks at a certain point, as well as the disclosure project development characteristics. Investors will be able to timely receive information via digital communication channels without fear of risks of privacy, integrity and authenticity of project data. Such characteristics are achieved by ensuring the security of data at the stage of their collection, transmission, storage, processing and receipt through the use of modern encryption technologies.

We consider DAO as a self-organizing dynamic information system, the goal of which is self-development in a digital world with a high level of risks and opportunities. It is expected that a significant number of decisions in digital markets will be made using big data and decentralized tools for their analysis, and the consumers of the information obtained in this way will be autonomous agents and decentralized autonomous organizations in P2P systems.

Despite the study of the meaning of data in peer-to-peer systems, the issue of using data in smart contracts and DAOs remains rather unexplored. However, it is worth paying attention to some works where the authors come close to studying data in the blockchain and the importance of their security. Thus, in the description of the Libonomy project, the idea of implementing a project using peer-to-peer data was presented [1], and the issue of the integrity of the data used was also raised in a number of articles on robonomics [2]. Within the framework of domestic science, the issue of using data using blockchain was discussed within the framework of studying the use of blockchain tools within economic systems. In addition, a number of papers describe advanced modern mechanisms for reducing time and costs when using data in peer-to-peer projects, while ensuring their security [4] [5] [6].

3. Nature and Role of Data in DAO

In the real world, information content increases logarithmically, not linearly. It is believed that in the modern world the period for doubling information is 18 months [19]. In information theory, this looks like a significant increase in the amount of information, including information processed per unit of time. In the biological world, the newer circuits are formed in the human brain, the more information a person is able to grasp in the simplest and most ordinary objects and events. In analogy with this, the same information networks can be created in DAO systems. However, raw information alone does not provide much value. Information becomes valuable after its interpretation and processing for the purpose of its further effective use. In peer-to-peer systems, this work is called peer-to-peer management. The flow of information, organized into qualitative structures, resembles neural connections in the human brain in its constantly renewing dynamic environment. At the same time, professionally structured connections have an advantage over human perception, since such connections cannot be resisted by inconvenient information. The difference in the characteristics of the data of a conventional digital system from P2P data indicates the impossibility of using their traditional classification, processing and analysis methods [20].

Conventionally, information and data that are valuable in the DAO environment, including those that are significant for making investment decisions, can be divided into the following categories: personal information (data on DAO leaders, their qualifications and experience); technical information (technical data of the project, results of preliminary studies, created samples, expert

opinions, technical data sheet, technical forecasts, sensor data); financial information. At the same time, in the DAO system, it is possible to build analytical nodes capable of providing, in the required form, key information that potential investors would like to have before making any investment decisions in relation to the DAO or decisions in its system. Any financial information, including about income and expenses, the volume of services sold, information about assets can dynamically come to investors who have appropriate access to it. This information can be supplemented by real-time sensor data. Access to data can be provided through smart contracts tied to project tokens, confirming ownership of a stake in the project. Also, through other peer-to-peer tools. This raises the need for data management, as well as ensuring their security during their transfer and storage.

The role of information in the work of the DAO is obvious. Participants are interested in receiving key information for making any investment decision. Financial information also helps to identify trends in business development in its development to understand development trends and future results [13]. The so-called informational neural connections in the DAO make it possible to build a high-quality internal search by functions, users and semantic connections. Thus, each DAO can have its own search engine tailored to the needs of the participants and the goals of the DAO.

Since the launch of the Bitcoin system, projects have been developing related to the exchange of data in decentralized independent systems. The high cost and low bandwidth of p2p networks hindered the development of projects allowing to process and store large amounts of data. With a decrease in the cost of transactions on the network and an increase in speed, projects have become possible with the creation of a DAO, where the bulk of the work is concentrated on data management, while ensuring data security and eliminating vulnerabilities in smart contracts and protocols remain one of the urgent problems of DAO architects.

Table 1
Modern P2P Platforms and Their Features

Operator	Lunching	Operations per second	Transaction fees, USD $
Bitcoin	2009	7	23
Ethereum	2015	100 000	5
Polkadot	2020	1 000	0.5
Solana	2020	65 000	0.00025
Bitcoin Lightning Network	2021	1 000 000	0.00055

Modern systems promise to provide flexible data integration and exchange with low installation and maintenance costs. However, the creation of such systems raises many problems. In addition to the obvious scalability issue, the selection of appropriate semantics that can deal with arbitrary, even circular topologies, data inconsistencies or updates, and at the same time allow flexible reasoning, has been an area of active research [18]. An overview of data management in P2P systems focuses on the use of indexes, clustering, replication and query processing in such systems [18].

A decentralized environment is attractive for economic development, primarily the ability to quickly exchange information, while maintaining its integrity and autonomy. Data security is ensured by the digital peer-to-peer environment, which provides the ability for any kind of encryption and cryptography. The modern level of technology makes it possible to exchange information safely and cheaply, which should positively affect the development of the peer-to-peer economy.

In the modern world for companies of all spheres and types have an important role. Companies are struggling to respond to emerging threats and security challenges of big data in the traditional sense [36], including the need to study and understand the main risks. Fake Data Generation Employee Negligence Employee Theft Lack of Security Audits Lack of Security Spending Data Cleansing Problems Data masking are fairly well-researched risks for working with traditional data [18] [17]. By understanding the most serious threats, stakeholders can develop more effective mitigation and response measures. The same approach is observed in the study of the risks associated with the use of data in a peer-to-peer environment in order to use it for DAO purposes.

P2P systems do not require centralized management and are not developed under the control of a central authority. Each peer provides a piece of common information available from a distributed environment and acts as a client and a server on the system. The result is a completely decentralized architecture that is flexible and capable of handling dynamic changes in the system to which peers can join or exit at runtime [9]. Tools for ensuring data integrity and adaptability of topologies in P2P systems and application integration are described in [31]

4. Data Sources for DAOs and their Security

Blockchain technology is the main tool for securing P2P data today. As a fundamental technology for the creation and operation of cryptocurrencies, blockchain is a tool that allows you to securely conduct online transactions using smart contracts, implement transactions, store and process data, and much more. In blockchain technology, each P2P network node has its own real-time database, which constantly updates the data and takes a snapshot of the state of the data at the current time. Each of the nodes in the network offers its own block in the chain. Other nodes on the network check the block, receive it after checking, and write the block to the chain. Thus, it is believed that it is impossible to hack the network, since it is stored on several nodes in the network. Thus, the security of operations in blockchain networks is ensured by the following factors: decentralization of the system; reliability of encryption algorithms; control and verification system of blocks.

Scope refers to a wide range of data from multiple sources; Diversity refers to different types of data collected, for example, video, audio, images and text, from various sources such as sensors, social media, smartphones, others; Speed refers to the speed at which data is collected and processed. Big data research focuses on methods, technologies, systems, practices, methodologies and applications that transform big data into useful, relevant and timely information, helping an enterprise to better understand its business and market conditions and make appropriate decisions [26].

The availability of big data from a variety of sources, with different data formats and sizes, can provide a more complete picture of the borrower. P2P lending platforms use a wide range of data to assess credit risk, while traditional banks may not have the technical capacity or analytical skills to leverage these new forms of data. Moving beyond traditional simplified credit risk indicators such as applicant assets, existing liabilities and FICO scores, P2P lending platforms analyze more dynamic data points from public websites, agencies, and public records [26].

5. Decision Making Model in DAO

The digital nature of the blockchain and its capabilities allow the use of any programmable approaches, including the use of autonomous economic agents, machine learning blocks, decision-making systems, automatic data retrieval, etc. Such tools can independently, or using other tools, conduct a search data, process them and independently make decisions.

As an example, below is one of the decision-making models for DAO, based on the management of data. The choice of the most optimal (digital) solution from offered decisions (by participants, managers, specialists, etc.), that should be solved automatically (or by way of comparison) is carried out by comparing the possible benefits, each of which is calculated using the following formula:

$$Dc = \sum y - \left|\sum x\right| - |a| - |b| - |c|, \quad (1)$$

where,

y - discounted future benefits with a positive result, taking into account the probabilities.

x - discounted losses that can occur in case of a negative result, taking into account the probabilities.

a - offered solutions cost, taking into account the probability of failure.

b – additional expectations from a positive result

c - discounted indirect costs associated with the decision.

Benefits and losses, as well as the cost of a solution, can be expressed both in direct price, expressed in electronic digital units, and in the cost of resources. In turn, each of the parameters can be calculated as follows:

$$y = \sum \left(\frac{y_n}{(1+R)^{tn}}\right) + \left(\frac{y_n}{(1+R)^{tn}}\right) * P, \quad (2)$$

$$x = \sum \left(\frac{x_n}{(1+R)^{t}}\right) + \left(\frac{x_n}{(1+R)^{t}}\right) * (1-P), \quad (3)$$

$$a = \sum \left(\frac{a_n * WP_n}{(1+R)^{TPn}}\right), \quad (4)$$

$$b = \sum \left(\frac{b_n}{(1+R)^{TFn}}\right) + b_n * (1+R)^{TFn}, \quad (5)$$

$$c = \sum (c_n * (1+R)^{TVn}), \quad (6)$$

where,

R - discount rate (rate proposed by validing of the principal cryptomoney (cryptoassets))

P - probability of a positive result when implementing a specific decision

t - time required to implement the solution

TP - time point for payment (resource costs)

WP - weights of resource payment values

TF - time of payment of direct costs for the solution

TV - the time of payment for the payment of indirect costs for the implementation of the solution

The results of applying this model using these hypothetical solutions after implementing the model in the Matlab environment are as follows:

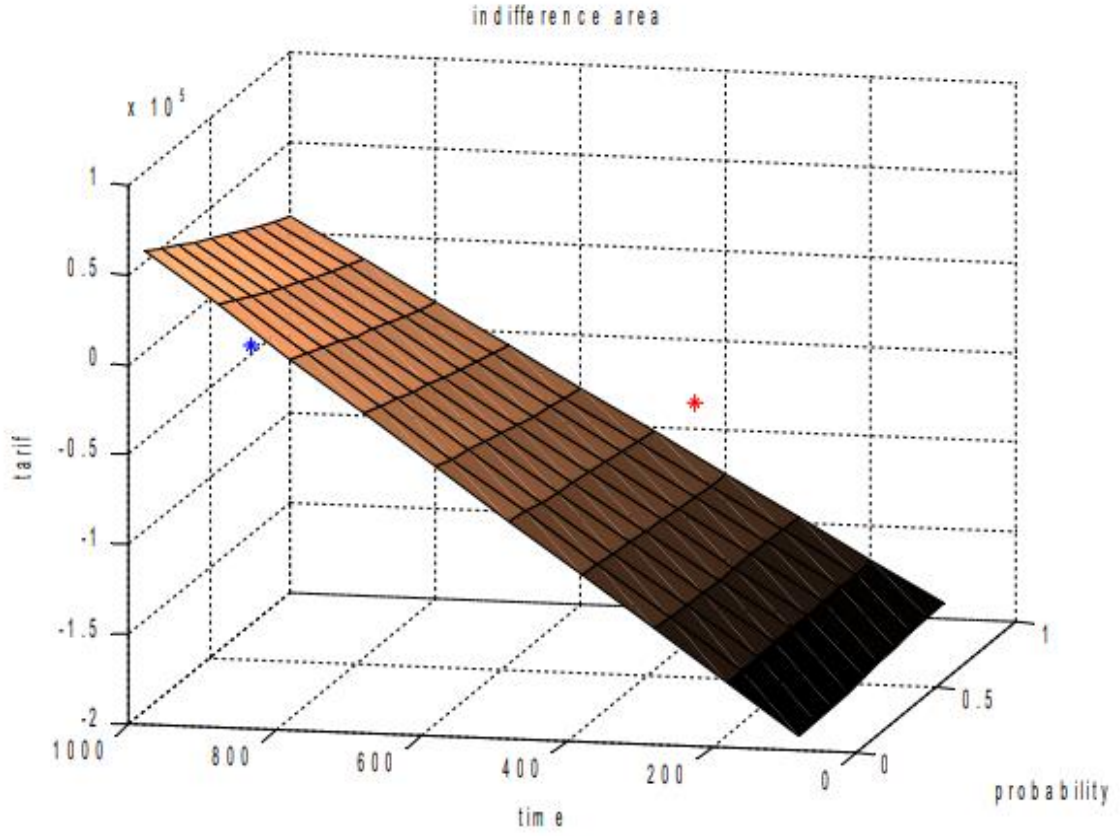

Figure 1: Decisions indifference planes

The plotted graph characterizes the planes of decisions indifference, where possible benefits are equal to losses. In this case, the points characterize each of the solutions in their weight of benefits (above the plane) and losses (below the plane).

A number of parameters, such as discount rate, timing of events, possible decision costs and probabilities, can be calculated in the DAO, either through the involvement of experts or independent agents, or through automatic database searches.

6. Data Problems for DAO

A decentralized environment also saves personal risks, including those associated with a lack of user experience. For example, an inexperienced user might enter a wrong address and the money will be transferred to a completely different person or company. In this case, no return is possible [16]. However, it seems possible to develop and implement algorithms in DAO to control and reduce risks, including personal risks.

It is believed that a fundamental problem in most P2P systems is data placement and retrieval [37]. Due to its characteristic of decentralization, blockchain has properties of protection against unauthorized access, non-forgery, privacy protection and automatic execution of smart contracts, due to which blockchain technology has a wide range of application scenarios, including use for storing data and recording transactions. The process of verifying, accounting, storing, maintaining and transmitting data in the blockchain is based on the structure of a distributed system, and not on a centralized mechanism for building trust relationships between nodes. The underlying blockchain data layer is supported by techniques such as hashing, asymmetric encryption, Merkle tree and timestamps [14].

The blockchain-based p2p data storage scheme has a significant improvement in system performance compared to conventional cloud storage schemes [14]. Previous old blockchain systems

based on proof-of-work methods are characterized by slow data processing and high cost of operations. This problem can be solved using a tool such as creating a Lightning network. Such a network basically consists of two contracts: the sequence expiration revocable contract (RSMC) and the hash time fixed contract (HTLC). Decentralized data storage based on blockchain is provided by cryptographic methods, including tools such as the Lightning Network technology and remote data integrity confirmation technology [24].

Expiration of the sequence can solve the problem of fast two-way transmission between the two sides of the channel. The hash time blocking contract solves the problem of transmission between nodes. These two types of trading portfolios form a lightning fast web. The payment method in this system is basically a one-way payment between two users, so the system basically uses a revocable contract with an expiration date to implement unlimited fast offline transfer between two users. The load of data and the amount of data entering the network can be determined by the tools for characterizing the network behavior of P2P traffic. For example, a developed measurement method, the Content Transfer Index (CTI), distinguishes between two classes of P2P traffic behavior: download and signaling traffic profile. If the download traffic is based on the analysis of the content transfer, the second is mainly related to the presence of an overlay network and possibly a search service. A way to separate download traffic from signaling traffic is to implement a protocol analyzer [12].

Data management issues in DAOs that need to be addressed when dealing with the scale and instability of such systems include:

- Location of data: peers must be able to refer to and find data stored in other peers
- Query handling: Upon request, the system must be able to discover peers that provide the appropriate data and execute the request efficiently.
- Data Integration: When data sources shared in the system follow different schemas or views, peers should still be able to access that data, ideally using the data view used to model their data.
- Data consistency: If data is replicated or cached in the system, maintaining consistency between these duplicates is a key issue [21].

However, despite their advantages, P2P systems offer limited data privacy guarantees. They can be viewed as hostile because data, which may be confidential or confidential, could be available to everyone (potentially untrustworthy partners) and used for everything (for example, for marketing, profiling, fraud, or for actions contrary to the preferences or ethics of the owner). Several P2P systems offer privacy mechanisms such as OceanStore, Past, and Freenet. However, these solutions are not enough [22].

Ensuring anonymity in the system is required at the following levels: personal data and access to data and the system, personal priorities and hobbies, data from social networks and the Internet environment [27]. An overview of current solutions for maintaining data privacy in P2P systems and a complete solution based on HDB (Hippocrates Database) is being developed in more detail [22]. Authorization and privacy management is ensured by controlling the availability of data at the peers. In general, each peer in the system can independently authorize access to its data in response to guarantees of confidentiality or confidentiality of the data. Thus, each participant can independently determine the data privacy policy [20].

As example new blockchain storage "Mystiko", built on the basis of Apache Cassandra distributed database, offers a solution for storing big data. Mystiko supports high transaction throughput, high scalability, high availability, and full text search functionality. Mystiko provides big data with security, structure and meaning, and simplifies further big data analytics [23].

It is impossible to guarantee the absolute security of peer-to-peer data for, just as it is impossible to do this with respect to any other processes and technologies. Participants of the DAO, given the architecture of the organization, ways to reduce risks by encouraging and encouraging careful handling of data and carefully analyze the possible presence of fraud [16]. A digital outsourced security system is also possible if appropriate solutions are provided for by the DAO protocols.

Data management in distributed systems can be provided by distributed database systems that allow users to transparently access and update multiple databases on the network using a high-level query language [11]. The most popular in the market are two types of databases, such as relational (SQL) or non-relational (NoSQL). However, due to the peculiarities of the blockchain for DAO

purposes, it is necessary to adapt systems to the structure of the databases, due to problems with scalability, low transaction speed, and many others. We cannot completely replace traditional database architectures, so it is obvious to combine blockchain functions with existing databases [10].

Distributed database systems (DDBS) are used when data is fragmented and administration is concentrated on a single node. Solutions built on the basis of DDBS can solve the problem of managing several dozen databases [29]. The practical use of such databases with the help of artificial neural networks is described in the project for assessing the rating of tourist profiles [32].

In addition, the dynamic nature of the system can impose certain restrictions on the consistency and availability of data: if the rate at which data changes in the system is high, then the overhead of maintaining globally accessible indexes may become unacceptable as the number of peers in the system grows [37].

7. References

[1] Fredrik Johansson, Sarmad Khan, Hamza Gul Kakar, Muhammad Omaid, Libonomy: Artificial Intelligence-based Next Generation Blockchain, White Paper v1.0, Released 30th July, 2020. URL: https://libonomy.com/assets/pdf/white-paper-libonomy-v1.0.pdf

[2] Li B., Chen Y., Zuo Z., Huang J. (2022) Blockchain-based Data Integrity and Privacy Protection Method for Swarm Robotics. In: Jia Y., Zhang W., Fu Y., Yu Z., Zheng S. (eds) Proceedings of 2021 Chinese Intelligent Systems Conference. Lecture Notes in Electrical Engineering, vol 805. Springer, Singapore. https://doi.org/10.1007/978-981-16-6320-8_71

[3] S. Obushnyi, R. Kravchenko and Y. Babichenko, Blockchain as a Transaction Protocol for Guaranteed Transfer of Values in Cluster Economic Systems with Digital Twins, 2019 IEEE International Scientific-Practical Conference Problems of Infocommunications, Science and Technology (PIC S&T), 2019, pp. 241-245, DOI: https://doi.org/10.1109/PICST47496.2019.9061233

[4] Gang Wang, Zhijie Jerry Shi, Mark Nixon, and Song Han. 2019. SoK: Sharding on Blockchain. In Proceedings of the 1st ACM Conference on Advances in Financial Technologies (AFT '19). Association for Computing Machinery, New York, NY, USA, 41–61. DOI: https://doi.org/10.1145/3318041.3355457

[5] Yizhong Liu, Jianwei Liu, Marcos Antonio Vaz Salles et al., "Building Blocks of Sharding Blockchain Systems: Concepts, Approaches, and Open Problems", DOI: arxiv-2102.13364

[6] M. Conoscenti, A. Vetrò and J. C. De Martin, "Hubs, Rebalancing and Service Providers in the Lightning Network," in IEEE Access, vol. 7, pp. 132828-132840, 2019, DOI: 10.1109/ACCESS.2019.2941448.

[7] Carlsson, A., et al. Sustainability Research of the Secure Wireless Communication System with Channel Reservation. 2020 IEEE 15th International Conference on Advanced Trends in Radioelectronics, Telecommunications and Computer Engineering (TCSET), 2020. https://doi.org/10.1109/tcset49122.2020.235583

[8] V. Buriachok, et al., Invasion Detection Model using Two-Stage Criterion of Detection of Network Anomalies, Cybersecurity Providing in Information and Telecommunication Systems (CPITS), pp. 23–32, Jul. 2020.

[9] D. Calvanese et al. Data management in peer-to-peer data integration systems. Global Data Management, pages 177–201, 2006.

[10] https://www.researchgate.net/publication/339297222_Challenges_of_Implementing_SQL_Database_on_a_Blockchain, DOI: 10.13140/RG.2.2.32969.90729

[11] Valduriez P., Pacitti E. (2005) Data Management in Large-Scale P2P Systems. In: Daydé M., Dongarra J., Hernández V., Palma J.M.L.M. (eds) High Performance Computing for Computational Science - VECPAR 2004. VECPAR 2004. Lecture Notes in Computer Science, vol 3402. Springer, Berlin, Heidelberg. https://doi.org/10.1007/11403937_9

[12] R. Bolla, M. Canini, R. Rapuzzi and M. Sciuto, "Characterizing the network behavior of P2P traffic," 2008 4th International Telecommunication Networking Workshop on QoS in Multiservice IP Networks, 2008, pp. 14-19, doi: 10.1109/ITNEWS.2008.4488123.

[13] https://www.ceps.eu/ceps-publications/business-models-and-economics-peer-peer-lending/

[14] https://iopscience.iop.org/article/10.1088/1742-6596/1237/4/042008
[15] D. Yue, R. Li, Y. Zhang, W. Tian and C. Peng, "Blockchain Based Data Integrity Verification in P2P Cloud Storage," 2018 IEEE 24th International Conference on Parallel and Distributed Systems (ICPADS), 2018, pp. 561-568, doi: 10.1109/PADSW.2018.8644863.
[16] Blockchain as the Main Tool to Ensure P2P Security
[17] Washbourne, L. (2015). A Survey of P2P Network Security. ArXiv, abs/1504.01358.
[18] F. OTTO, D. P. MIREMBE, and M. Muyeba, "A Model for Data Management in Peer-to-Peer Systems," International Journal of Computing and ICT Research, vol. 1, pp. 67-73, 2007.
[19] R. A. Wilson, Quantum Psychology, 2004. URL: https://media.oiipdf.com/pdf/176bc78a-6076-407a-865c-a206389ebc13.pdf
[20] Calvanese, D., De Giacomo, G., Lembo, D., Lenzerini, M., & Rosati, R. (2006). Data management in peer-to-peer data integration systems. Global Data Management, 177-201.
[21] Sung, L. A., Ahmed, N., Blanco, R., Li, H., Soliman, M. A., & Hadaller, D. (2005). A survey of data management in peer-to-peer systems. School of Computer Science, University of Waterloo.
[22] Jawad, M., Serrano-Alvarado, P., & Valduriez, P. (2013). Supporting data privacy in p2p systems. In Security and Privacy Preserving in Social Networks (pp. 195-244). Springer, Vienna.
[23] Bandara, E., Ng, W. K., De Zoysa, K., Fernando, N., Tharaka, S., Maurakirinathan, P., & Jayasuriya, N. (2018, December). Mystiko—blockchain meets big data. In 2018 IEEE international conference on big data (big data), pp. 3024-3032. IEEE.
[24] Zhu, Y., Lv, C., Zeng, Z., Wang, J., & Pei, B. (2019, June). Blockchain-based decentralized storage scheme. In Journal of Physics: Conference Series (Vol. 1237, No. 4, p. 042008). IOP Publishing.
[25] Hu, Z., et al., Development and operation analysis of spectrum monitoring subsystem 2.4–2.5 GHz range. Lect. Notes Data Eng. Commun. Technol. 48: 675–709 (2020). https://doi.org/10.1007/978-3-030-43070-2_29
[26] Yan, J., Yu, W., & Zhao, J. L. (2015). How signaling and search costs affect information asymmetry in P2P lending: the economics of big data. Financial Innovation, 1(1), 1-11.
[27] Daswani, N., Garcia-Molina, H., & Yang, B. (2003, January). Open problems in data-sharing peer-to-peer systems. In International conference on database theory (pp. 1-15). Springer, Berlin, Heidelberg.
[28] I. Bogachuk, V. Sokolov, V. Buriachok, Monitoring subsystem for wireless systems based on miniature spectrum analyzers, in: 2018 International Scientific-Practical Conference Problems of Infocommunications. Science and Technology (2018). https://doi.org/10.1109/infocommst.2018.8632151.
[29] King, R. A., Hameurlain, A., & Morvan, F. (2010). Query routing and processing in peer-to-peer data sharing systems. arXiv:1005.5438.
[30] Peer-to-peer data access model in the energy sector, https://treasury.gov.au/sites/default/files/2021-05/c2021-168954-cdr_design_paper_peer_to_peer.pdf
[31] Costa, F., Silva, L., Kelley, I., & Taylor, I. (2008). Peer-to-peer techniques for data distribution in desktop grid computing platforms. In Making Grids Work (pp. 377-391). Springer, MA.
[32] Moral-Cuadra, S., Solano-Sánchez, M. Á., López-Guzmán, T., & Menor-Campos, A. (2021). Peer-to-Peer Tourism: Tourists' Profile Estimation through Artificial Neural Networks. Journal of Theoretical and Applied Electronic Commerce Research, 16(4), 1120-1135.
[33] Li, B., & Liao, X. (2013). Peer-to-peer in big data management. Peer-to-Peer Networking and Applications, 6(4), 361-362.
[34] Sen, J. (2011). Secure and privacy-aware searching in peer-to-peer networks. In Data Privacy Management and Autonomous Spontaneus Security (pp. 72-89). Springer, Berlin, Heidelberg.
[35] Lakhno, V., et al., Funding Model for Port Information System Cyber Security Facilities with Incomplete Hacker Information Available, Journal of Theoretical and Applied Information Technology 96(13), 4215–4225, 2018.
[36] Jaikar, S. P., & Nimbalkar, M. V. (2012). Verifying Data Integrity in Cloud. International Journal of Applied Information Systems, 3(1).
[37] Halevy, Z. I. A., Rodrig, M., & Suciu, D. (2001). What can databases do for peer-to peer. WebDB. In WebDB.