# Autonomy of Economic Agents in Peer-to-Peer Systems

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**Abstract**

The transition from a traditional economy to a digital economy based on Web 3.0 and blockchain technologies is accompanied by some changes in the structure of relations between participants. Such changes relate to the blurring of the concept of the ultimate beneficiary and the center of responsibility in the case when certain digital categories are behind this or that type of relationship, devoid of the center of control traditional for the economic system. As a rule, such relations between participants have a high level of autonomy and a low level of control by the state or traditional economic organizations. Thus, autonomous economical agents, as completely independent actor, using peer-to-peer economy platforms have the potential to have a large impact on values and behavior in society. Understanding of the economical level of autonomy in peer-to-peer systems of such agents requires analysis of their role in such and design of the control mechanisms in order to determine the benefits from positive effects and at the same time mitigate negative consequences from possible mistakes. This requires a structured overview of the levels of agent autonomy and its impact on the existing system. The purpose of this article is to structure the study of economic agent autonomy in peer-to-peer systems, taking into account the possibilities of the digital environment. The article also provides an overview and analysis of the main technological developments in the field of autonomous economic agents and decentralized autonomous organizations, characteristics and framework of economic autonomy of the agents, taking into account digital environment of peer-to-peer digital systems.

**Keywords**

Autonomous economic agent, Web 3.0, peer-to-peer, blockchain, DAO, decentralized autonomous organization, P2P system.

## 1. Introduction

Autonomous economic agents (AEA), as well as Decentralized Autonomous Organizations (DAO) [1], being designed in the peer-to-peer digital systems and acting independently in accordance with their internal rules represent a new type of non-personalized (not established) subjects of economic relations described once in the works of M. Porter [2]. It is believed that in the new decentralized (peer-to-peer) systems it will be difficult to determine the final personalized participant (stakeholder or beneficiary) due to its digital anonymity, taking into account the possibility of its complete replacement by a digital algorithm (Digital Twin) [3]. The decentralization of new technologies makes it possible to completely or partially refuse state protection and supervision over the activities of such entities, while contributing to faster, safer and cheaper operations. The fact that digital machines (robots and computers) have proven their effectiveness in many areas such as finance, trade and banking, information storage and analysis confirms their growing role in the digital economy, as well as their effective integration with existing economic systems.

The application of blockchain technology, machine learning, artificial intelligence [4], digital identity, smart contracts and robotics opens up new opportunities for peer-to-peer cooperation

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and partnership. A decentralized agent will be able to make direct peer-to-peer transactions together with a person, or other similar digital agent [5], which in turn makes it possible to develop the idea of the economic ability of robots and bots to conclude agreements and make transactions, where both a person and a robot can act as a party without the necessary economic legal personality in the traditional sense. The coexistence of robots and humans in the peer-to-peer systems suggests the need to study the interaction between humans and robots, including within the framework of behavioral economics, law, game theory, and cryptoeconomics.

Peer-to-Peer Economy Platforms are defined in scientific papers as digital platforms where providers meet directly with users without intermediaries to complete a transaction with a component of the physical world where there is no transfer of ownership [6]. This means that participants enter into relationships with each other in order to create added value using the capabilities of peer-to-peer platforms. One such possibility is the creation of digital autonomous agents.

Modern technologies of peer-to-peer systems make it possible to talk about the further development of economic relations and the role of autonomous economic agents in them with accelerating information flows, including paired with machine learning and artificial intelligence (AI) technologies. The possibility of achieving a high level of information security, internationalization of databases, in the conditions of a developed system of sensors and artificial intelligence represent the potential for the development of the digital economy while optimizing a number of processes and accelerating the development of information technologies. This represents an undeniable potential for a number of digital realms with the increasing value of data and information as their use cases expand.

The growth of the platform business has been driven by the Internet and mobile technologies, as well as the rapid development of analytics, artificial intelligence (AI) and big data, as well as changing consumer preferences and consumption patterns [7]. Platform business models in general, and the sharing economy in particular, have led to the creation of industries without intermediaries, as well as the possibility of creating autonomous agents.

However, attempts to combine modern digital technologies in traditional systems have revealed a number of problems associated with their interaction and synchronization. Any centralization (public or private) of each of the existing modern technologies creates a number of obstacles for their optimal and sustainable interaction. The creation of peer-to-peer economic systems with elements of decentralization will most likely create conditions for the interaction of digital technologies and the emergence of a new type of economic relations with the participation of autonomous economic agents. Having the ability to freely interact with each other, autonomously and securely exchange data and digital assets, share forecasts, autonomous economic agents will undoubtedly become a full-fledged subject of economic relations in the future, and, possibly, with the acquisition of their own separate legal status. At the same time, the study of ways of interaction of economic autonomous agents will be the subject of close study of both technical and commercial specialists.

## 2. Economic Autonomy of an Agent in Peer-to-Peer Systems

In a number of studies devoted to autonomous economic agents, the latter are understood as intelligent autonomous systems that act independently, but on behalf of and on behalf of users (people, participants, organizations) to solve the set economic tasks within the framework of the granted powers. Such tasks may include negotiating with other agents, seeking information, interpreting past experience, and predicting future events. Agents have mobility properties; therefore, they have high performance in dynamically distributed systems. The use of well-designed agents in peer-to-peer systems improves the efficiency of operations and data exchange, which ultimately leads to a critical reduction in transaction costs. Since autonomous agents can provide intelligent services through peer-to-peer applications, artificial intelligence algorithms can also be successfully implemented on A2A (agent to agent) platforms. At the same time, the use of such forms of interaction is available to all traditional agents, including government regulators (Fig. 1).

To understand the role and place of an autonomous agent in the economic system, we can give it the following definition: An autonomous economic agent (AEA) is an intelligent agent acting on its own behalf or on behalf of the owner with limited intervention from the owner or other agents, or without such interference, and whose purpose is to create economic value for its owner or search for its own resource. As a rule, AEAs have a narrow goal with a purposeful focus, assuming some economic benefit. It is believed that the autonomous operation of an agent is achieved through the use of peer-to-peer systems and certain algorithms (smart contracts) that underlie the architecture of agents and allow secure transactions without the participation of third parties. At the same time, they will be autonomous if such a model does not require input from an individual user.

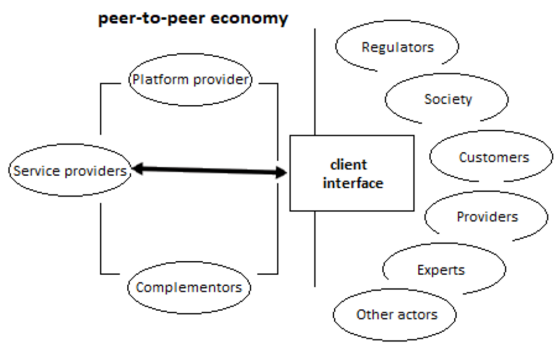


**Figure 1**: Actors involved in peer-to-peer economy

AEAs are also special in that they are created to generate some economic value through specialized software modules or digital skills. AEA independently acquires new skills, either through the direct use of software modules, or through independent or collective learning. Examples of the use of AEA can be the acquisition of digital assets at a bargain price, having the appropriate negotiation skills, while allowing the possibility of interacting with another agent representing the autonomous other party to the transaction.

## 3. Features of Autonomy of Economic Agents

It is believed that the first autonomous digital agent was a device called the Turing machine, developed in 1948 by Alan Turing, an English mathematician, logician and cryptographer [8]. The machine was a computing environment with two independent agents. One agent generated tasks, and the other solved them. Thus, the opinion arose that agents receiving information from the external environment can then act independently, while providing feedback and communication. In addition, Turing hypothesized that cryptographic peer-to-peer systems in their entirety can represent an independent intelligent machine.

Early autonomous agents were also presented in the “Mathematical Theory of Communication” published in 1948 by the American electrical engineer and mathematician Claude Elwood Shannon [9], where the author develops the topic of electronic communication, including with the participation of independent (autonomous) algorithms. Studying agents with their communicative properties, the latter were endowed with the following characteristics which describe the levels of autonomy of a digital agent:

- Situationality is the ability of the agent to interact autonomously with the environment through the use of sensors and analytical modules.
- Autonomy is the ability of an agent to determine its actions independently without external interference from a person or other agents of the network.
- Consistency is the ability of the agent to work with abstract categories and draw logical conclusions after observing and generalizing information.
- Efficiency is the ability to perceive various states of the environment and respond in a timely manner to any changes.
- Purposefulness is the ability of an agent to extract from the information flow the data necessary to implement the tasks and activate the appropriate algorithms, and not just respond to state changes, as well as the ability to adapt to any changes in a dynamic environment.
- Social behavior is the ability of an agent to interact with external sources and the ability to share knowledge with other agents to jointly solve a specific problem [10].

Thus, the structure of the interaction of autonomous agents can be summarized in the following form (Fig. 2).

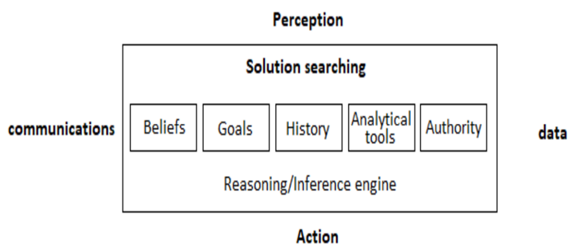


**Figure 2**: Typical building blocks of an autonomous agent

It is believed that autonomous agents are endowed with the following properties: rationality is an individual property of intelligent agents, as well as cooperative multi-agent systems or teamwork. Following the economic approach, the agent must maximize the utility function. To study the properties of autonomous agents in 1944, von Neumann and Morgenster created Decision Theory, combining utility theory with probability theory. In decision theory, a rational agent is an agent that chooses an action to maximize expected utility, where expected utility is defined as the actions available to the agent, the probabilities of certain outcomes, and the agent's preferences for those outcomes. In multi-agent scenarios where an agent must interact with other agents, game theory is also a powerful predictive and analysis tool. To solve problems with a sequence of multi-agent scenarios, in the late 1950's, Bellman developed Dynamic Programming based on the use of decision theory methods. Particular attention was paid to the interoperability of agents as the ability to interact, communicate and share knowledge using communication tools.

Decentralized Autonomous Corporations (DACs) and Decentralized Autonomous Organizations (DAOs) are seen as forms of new and innovative corporate structures that will allow new venture ideas to take root and infiltrate business structures and have the characteristics of an autonomous agent using blockchain technology and peer-2-peer systems and with a specific goal as to generate revenue. It is understood that such an autonomous agent exists in the cloud, performing functions that are valuable to their owners. All operations that need to be performed will be performed by the code, the implementation of the business logic of the DAC within the algorithm and over the blockchain [11]. Thus, the research of the second half of the $20^{th}$ century in relation to autonomous agents acquires a new meaning in the context of peer-to-peer systems.

The digital autonomy and independence of an agent based on peer-to-peer systems significantly distinguish it from other traditional participants in economic relations. It is believed that an economically independent agent should be able to independently make decisions depending on their beliefs (modules). Therefore, the agent has exclusive control over the activation of its services and skills, and can also refrain from performing a task on its own. Thus, the system of beliefs (behaviors) of an agent is arbitrarily imprinted in its internal architecture. The internal architecture of agents and how they react to a dynamic environment is highly dependent on agent autonomy. Such an architecture can be designed (built) and represented by abstract and concrete classes of beliefs, desires, and intentions (BDIs), which essentially lead to what we call mental state elements. The goal of an agent is to achieve a specific set goal by following a carefully crafted hierarchical plan to achieve it. An effective agent must have the ability to recognize the current situation and respond appropriately to it based on their belief system. Therefore, the agent must be able to determine its current state in relation to the goal being pursued.

An autonomous agent independently makes decisions based on the conditions that the agent has at its disposal. It is characteristic that the agent's decisions are logically limited. The beliefs involved in decision-making are mainly related to states (collected data about the past, present, or forecasts of the future, one's own skills, states, and the capabilities of other agents). The agent's decisions are also constrained by previous decisions regarding the resources to use. For example, if an agent decides to purchase information from one database, it cannot decide to purchase it from another database at the same time. Also, an agent cannot unilaterally revoke obligations that he has to other agents and that other agents have signed up to fulfill, but he can cancel those obligations that other agents have to him. It is extremely important for the agent to know the temporary or other criterion for terminating the task, otherwise he risks getting stuck in the loop of finding the best solutions.

As the understanding of the nature of autonomous agents in the economic system, it became necessary to determine the place of such an agent in the system of economic relations, as well as endowing him with some signs of economic subjectivity, taking into account his autonomous participation in transactions. Having their own structure, autonomous economic agents act autonomously and pursue economic goals, the achievement of which was delegated to them by a certain beneficiary (the owner of the agent). The autonomous agent framework facilitates user experience through automation, supports modularity, reuse of complex problem solutions and machine learning capabilities, and predicts future states that promote agent autonomy. The use of autonomous agents is currently already available in the multi-agent peer-to-peer system for trading baskets of tokens [12].

Each agent in the real world can represent an individual, a group of people or an organization, and perform certain actions in their interests, maximizing economic utility. To this end, agents must be aware of their owners' preferences and values [13]. The goal of each agent is to maximize the outcome for their master by engaging in profitable trades based on their preferences [14]. This concept rejects the autonomous subjectivity of autonomous economic agents, in which agents can achieve complete independence with autonomous awareness of their needs and independent decision-making. We can assume that such independence may not always meet the interests of the owners of such agents.

Agents involved in transactions, in accordance with their own preferences, can direct their efforts to find strategies and a set of optimal solutions. In this case, strategies may include the following: finding suitable agents for trading; trading with them; determining the needs of other agents to achieve the optimal trading sequence, etc. It is believed that in this case the agent demonstrates purposeful behavior, while having the ability to respond to state changes. From a technical point of view, agents have a so-called main loop and an event loop. The first controls the proactive behavior of the agent, in which the agent moves towards achieving its goal at each cycle. On the other hand, the event loop is responsible for handling incoming events. Events are presented as incoming messages with their subsequent processing in the main loop [15].

## 4. Levels of Autonomy of the Economical Agents

Depending on its functional architecture, an economic agent may demonstrate different levels of autonomy in relation to its developer [16]. These levels are classified as follows:

*Reactive agents* are rather simple agents in their functionality, which consist only of a program that maps each possible sequence of perception into the corresponding action. They need built-in knowledge that uniquely defines their behavior. They are characterized by limited autonomy and flexibility. They are only effective in the environment for which they were designed. Depending on the functions of reactive agents, they are classified into a Search Agent, a Reflective Agent, and an Agent with an internal state. The simplest of this category of agents is the Search Agent. The agent uses its database to remember and track the entire sequence of observations. Increasing such a given database becomes a problem for quick decision making.

The reflex agent is a fairly simple agent that simply follows the "condition-action" rules. The agent perceives a certain state and acts in a certain way, without referring to the sequences of perception. This type of agent has no autonomy at all, because the choice of its actions is completely built-in. It is possible to supplement the agent's algorithm with the ability to learn. The mathematical model of the reflex agent can have the following form. The action a to perform at time $t + 1$ can be expressed by the following state function s at time t.

$$a(t+1) = f(s(t)), \tag{1}$$

Stateful agents are agents that make decisions based on their internal state. The action a to be performed at time $t + 1$ can be expressed as a function of the expression of the state's at time t and the current internal state x(t).

$$a(t+1) = f(x(x(t), s(t)) \tag{2}$$

$$x(t+1) = g(x(t), s(t)) \tag{3}$$

Agents with an internal state can also, in turn, be classified depending on the complexity of their algorithms into the following types:

- Deliberative agents, where the action to be performed is calculated based on the state of the environment, as well as taking into account the expected impact on it. In other words, the agent motivates his actions based on the analysis of external factors.
- Goal-oriented agents are agents who make decisions given the description of desirable situations as goals.
- Utility agents are agents that can compare different states of the environment when choosing a goal.

*Planning agents* are a type of more complex agents that have more sophisticated built-in knowledge about the set of possible actions, understand the consequences of their actions, and also have some knowledge about the mechanisms of control of the environment. This type of agent is more autonomous than the previous type, since it can choose combinations of actions, but cannot be considered completely autonomous due to a number of restrictions.

*Fully autonomous agents* have built-in knowledge specific to scheduling agents and a powerful learning engine. Thus, his behavior is actually determined by his own experience. This type of agent can define new prerequisites and consequences for its actions, as well as rewards for each of its actions. Examples of successful learning methods are neural networks. Artificial agents can use them to build and continually update decision models.

## 5. Features of the Environment for the Interaction of Autonomous Agents

It is believed that AEA can be effectively involved in the following economic areas: finance; transport and logistic; supply and quality control; energy market; social networks; auctions and IoT, databases and registries; personal ratings; commercial arbitration; co-investment, etc. AEAs potentially replace resellers by directly connecting all participants in production and supply chains, while reducing the need for human intervention and significantly saving time to meet certain needs. Such a system allows multiple agents to interact continuously and autonomously with each other without the need for any third-party guidance.

In order to ensure interaction between an agent and a person, as well as autonomous agents among themselves, including with the use of AI technology, digital peer-to-peer ecosystems can be created with the possibility of creating and existing autonomous agents that collectively, autonomously and continuously work on solving problems. At the same time, in addition to the described characteristics, there is an opinion about the possibility of endowing such autonomous agents with modular structures based on such philosophical categories as ontology, belief, desire, intention, abstraction, objectivity, semantics and social ability, which provides additional advantages when interacting with a person and traditional systems.

It is believed that the peer-to-peer environment provides the necessary level of security for the operation of an autonomous agent. For an autonomous agent protocol to work effectively, it must meet the following conditions: be stable in the short term and unchanged in the long term; be scalable, which means the ability of the protocol to cope with growing and large volumes of operations, which affects the throughput of the system; be decentralized, meaning no control or authorization by third party groups or individuals. In addition, the peer-to-peer environment for the operation of autonomous agents must meet the following requirements: the ability to split the block chain to increase consistency and scalability; the ability to program smart contracts and develop programs compatible with the capabilities of machine learning and artificial intelligence, as well as the ability to transfer these capabilities to other agents; an open economic structure (OEF) embedded in an intelligent database (a dynamic environment in which agents reside and receive input); support for fixed-point arithmetic to ensure accuracy and determinism for all operations and transactions [17].

According to Russell and Norvig, the types of conditions for the effective existence and operation of independent agents are classified and distinguished [18], presented in table 1 below. Each of the types of such conditions (environment) also determines the degree of its suitability for convenient and efficient use of the agent. It is believed that the most complex and inefficient type of environment for an agent is an inaccessible, non-deterministic, dynamic and continuous environment. Peer-to-peer systems, having different environment characteristics, offer different solutions and tools that can be attractive to AEA.

**Table 1**

Types of autonomous agent environments

| Types | Characteristics |
|---|---|
| Available and unavailable | The level of information availability in the environment in which the agent can receive complete, accurate and up-to-date information about its state (physical and virtual world, the Internet). |
| Deterministic and non-deterministic | Levels of expected guaranteed results in an environment for a particular action or set of actions and the absence of uncertainty. |
| Static and dynamic | The ability of an environment to maintain its state as a result of the existence and activity of agents within it, experiencing constant changes caused by other operations beyond the control of individual agents. |
| Discrete and continuous | An environment is discrete when it involves a fixed finite number of actions or calculations. |

An environment that combines the criteria of security, speed and low cost of transactions will be attractive to the user. Thus, the combination of blockchain technology (peer-to-peer systems) and agent systems opens up many opportunities for digital partnerships, where the conditions for interaction with other peer-to-peer platforms are important, including the ability to build an ecosystem of agents based on their resources. Tools for data exchange and interaction between different systems can be technologies for combining peer-to-peer systems, such as: parachains; paranity; oracles, multiplexers (Multiplexer), simulators, etc.

An ecosystem of agents can provide a system for assessing the characteristics and states of agents in order to provide system participants with information about the status of an agent and the conditions for interacting with them. Such ratings can arise based on the collected information about agents (through the reporting module of the ecosystem), the history of their interactions with other agents, the number of positively completed tasks, as well as rating classifications and rating models.

An agent operating in an environment must be able to understand the various nuances of the states of such an environment in order to be able to predict future states. If an agent can predict the future, this means that he can honestly carry out his actions without favoring any one action. This concept is called the concept of justice, considered by Nassim Francez in the late 80's [19]. The ability to make predictions greatly helps this agent to understand the consequences of his decisions. Agents must be motivated to negotiate among themselves in order to make the best possible decisions to achieve the desired outcomes. So that agents do not get stuck on a separate process, the concept of interaction provides for the priority of interaction in real time, the interaction of agents has a certain time frame, and the result must be obtained as quickly as possible, etc.

The ideal agent will be characterized by the ability to strike a balance between goal-directed and reactive behavior. In other words, agents must be able to achieve their goal, stop pursuing the goal, know when to do it—all this depends on pre-existing environmental conditions that either positively or negatively affect its achievement. All this is determined by predetermined conditions, such as time limits, consequences, performing or stopping the specified action. Such conditions can be agreed in advance by built models, for example, real option models. Therefore, based on the analysis of the dynamic states of the environment, the agent can determine its own behavior, referring to its goals and beliefs.

The use of multi-agent systems (MAS) also provides an opportunity for collective agent learning, where some autonomous agents with competitive or mutual interests increase their understanding of the state and behavior in the peer-to-peer ecosystems with which they are associated. Ideally, this will allow them to optimize their search for a solution to a particular problem. In turn, synergistic smart contracts (SC) allow developers to use the potential of the underlying blockchain infrastructure by automating and executing a program or transaction protocol in accordance with the legal (logical) terms and agreements of the contract. Synergistic smart contracts are an extension of the concept of smart contracts, allowing off-grid computing to be included in multi-party agreements. Such contracts allow the developer to perform offline operations using machine learning models and smart databases.

The presence of digital skills and abilities form the basis of autonomous capabilities that AEAs can dynamically use to increase their effectiveness in various situations. The fact that an agent has one or more skills will characterize its competitiveness in the ecosystem (the ability to work with complex tasks). Subscribing to individual skills may depend on the strategy chosen by the agent. The presence of several skills in an agent provides a system of skills priority in case of their competition. Additional skills can be added as packs. The ecosystem may also provide for the possibility of creating various models, with the provision of access to them for individual agents.

It is believed that digital behavior (action) is one or more actions, as well as their absence, causing interactions with other agents initiated by the AEA. There are the following types of behavior:

- Cyclic (CyclicBehaviour): if the agent is active, the behavior remains active and is called again after each event.
- Fragmented (TickerBehaviour): a type of cyclic behavior in which a user-defined piece of code is periodically executed)
- One-time (OneShotBehaviour): performed once and self-deactivates.
- Model (Finite State Machine or FSMBehaviour): a computational model that can be used to model sequential logic to

represent and control the execution of sequential actions. In this model, fuzzy logic can also be used to expand the range of states to work with them, and using probabilities to determine behaviors.

Other types of agent behavior are also possible.

The digital interaction module provides for the skills of synchronization with other agents, the skills of negotiating and making transactions, the skills of subscribing to various protocols for dynamically determining the states of agents, the skills of remembering the history of transactions for the purpose of subsequent training or knowledge sharing, the skills of working with errors, etc. Thus, agents can interact for the purpose of jointly collecting data and information, making available their individual skills or models for data analysis and decision making, implementing information logistics strategies or risk assessment, joint control of sensors, evaluating the behavior of other agents (digital arbitrage), etc.

# 6. Conclusions

The use of independent agent technology in peer-to-peer systems along with artificial intelligence technology is considered fairly new. It is assumed that agents can be both autonomous and intelligent objects in the network, having a digital form in the form of a code, and reside at the nodes, or move between them. They are endowed with the ability to independently identify problems or receive tasks from users or other agents, as well as discover the necessary resources, communicate with other agents (negotiate) and offer suitable solutions. They are also good at learning from the past, updating their knowledge, and predicting future events. The main differences between agents and conventional software is the ability to independently coordinate, interact and self-learn. By working together, agents optimally allocate resources, which can be like teamwork to solve a problem. With the ability to quickly adapt to new conditions, the use of agent technology is suitable for peer-to-peer dynamic systems. Although agents have some level of dependency, they are endowed with communicative properties to jointly search for resources necessary to solve problems. Systems designed on the basis of agent technology must take into account all the characteristics of autonomous and intelligent agents in order to take advantage of them.

In fact, autonomous economics are a class of agents with the characteristics of digital entities that can make informed and rational decisions on behalf of their stakeholders. With peer-to-peer ledger technology based on a consensus mechanism to enable secure, high-performance, low-cost transactions. As a result, of the introduction of bridges between different types of peer-to-peer systems, we get a completely new information environment that facilitates the introduction of autonomous agents, in which autonomous economic agents can exist, discover and be discovered, communicate with each other, act as an intermediary and make transactions with a high level of security. The developer can use this environment to create agents of any caliber, purpose, use, and intent. The software package for peer-to-peer systems provides tools to minimize network traffic, maximize scalability and efficient use of resources. The use of agents to carry out commercial tasks in turn raises new questions regarding the determination of levels of efficiency in the use of resources and the accuracy of achieving goals. The capabilities of autonomous agents, based on elements and tools such as beliefs, intentions, and event prediction, will facilitate the use of autonomous agents in the digital economy, as well as their interaction with machine learning technologies, neural networks, artificial intelligence, and other advanced digital technologies.

# 7. References


[1] S. Obushnyi, et al., Ensuring Data Security in the Peer-to-Peer Economic System of the DAO, in Cybersecurity Providing in Information and Telecommunication Systems II, vol. 3187, 2021, pp. 284–292.

[2] M. E. Porter, M. R. Kramer, How to Reinvent Capitalism—and Unleash a Wave of Innovation and Growth.

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

[4] R. Dobre, et al., Authentication of JPEG Images on the Blockchain, in International

Conference on Control, Artificial Intelligence, Robotics & Optimization, 2018.
[5] M. J. J. Gul, et al., Blockchain based Healthcare System with Artificial Intelligence, in International Conference on Computational Science and Computational Intelligence, 2020.
[6] H. J. Scholl, et al., Studying the Effects of Peer-to-Peer Sharing Economy Platforms on Society, Electronic Government and Electronic, 2016. doi: 10.3233/978-1-61499-670-5-222,
[7] J. Wirtz Platforms in the Peer-to-Peer Sharing Economy, Journal of Service Management, vol. 30, no. 4, 2019, pp. 452–483, doi: 10.1108/JOSM-11-2018-0369.
[8] A. M. Turing, Computing Machinery and Intelligence, Mind a quarterly review of Psychology and Philosophy, vol. LIX, no. 236, 1950.
[9] C. E. Shannon, A Mathematical Theory of Communication, The Bell System Technical Journal, vol. 27, 1948, pp. 379–423, 623–656.
[10] P. G. Balaji, D. Srinivasan, An Introduction to Multi-Agent Systems, Innovations in Multi-Agent Systems and Applications 1. doi: 10.1007/978-3-642-14435-6_1
[11] K. N. Kypriotaki, E. D. Zamani, G. M. Giaglis, From Bitcoin to Decentralized Autonomous Corporations, Extending the Application Scope of Decentralized Peer-to-Peer Networks and Blockchains, in 17th International Conferenceon Enterprise Information Systems.
[12] D. Minarsch, et al., Autonomous Economic Agents as a Second Layer Technology for Blockchains: Framework Introduction and Use-Case Demonstration, in 2020 Crypto Valley Conference on Blockchain Technology. doi: 10.1109/CVCBT50464. 2020.00007.
[13] K. Atkinson, T. Bench-Capon, States, Goals and Values: Revisiting Practical Reasoning, Argument & Computation, vol. 7, 2016, pp. 135–154. doi: 10.3233/AAC-160011.
[14] D. Minarsch, et al., Trading Agent Competition with Autonomous Economic Agents, Science and Technology Publications, Lda.
[15] L. Padgham, M. Winikoff, Developing Intelligent Agent Systems: A Practical Guide, 2004. doi: 10.1002/0470861223.
[16] N. Fornara, Interaction and Communication among Autonomous Agents in Multiagent Systems, Dissertation. https://core.ac.uk/download/pdf/20637835.pdf.
[17] F. Kipchuk, et al., Investigation of Availability of Wireless Access Points based on Embedded Systems, in IEEE International Scientific-Practical Conference Problems of Infocommunications, Science and Technology, 2019, pp. 246–250. doi: 10.1109/picst47496.2019.9061551.
[18] S. J. Russell, P. Norvig, Artificial Intelligence A Modern Approach, 1995.
[19] N. Francez, Fairness. Spronger-Verlag, 1986.