Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

Dolna 17, Warsaw, Poland 00-773
Tel: +48 226 0 227 03
Email: editorial_office@rsglobal.pl

JOURNAL	International Journal of Innovative Technologies in Social Science
p-ISSN	2544-9338
e-ISSN	2544-9435
PUBLISHER	RS Global Sp. z O.O., Poland

ARTICLE TITLE	INTEGRATION OF BLOCKCHAIN TECHNOLOGIES AND MACHINE LEARNING WITH DEEP ANALYSIS
AUTHOR(S)	Dziatkovskii Anton.
ARTICLE INFO	Dziatkovskii Anton. (2022) Integration of Blockchain Technologies and Machine Learning with Deep Analysis. *International Journal of Innovative Technologies in Social Science*. 4(36). doi: 10.31435/rsglobal_ijitss/30122022/7918
DOI	https://doi.org/10.31435/rsglobal_ijitss/30122022/7918
RECEIVED	30 November 2022
ACCEPTED	22 December 2022
PUBLISHED	30 December 2022
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INTEGRATION OF BLOCKCHAIN TECHNOLOGIES AND MACHINE LEARNING WITH DEEP ANALYSIS

Dziatkovskii Anton
Blockchain Technology and Data Science specialist, Platinum Software Development Company, Australia
ORCID ID: 0000-0001-7408-3054

DOI: https://doi.org/10.31435/rsglobal_ijitss/30122022/7918

ARTICLE INFO

Received 30 November 2022
Accepted 22 December 2022
Published 30 December 2022

KEYWORDS

Machine Learning, Blockchain, Intelligence.

ABSTRACT

The successful development of the digital economy, which we can observe since the advent of the internet, is closely related to progress in several "frontier technologies" (frontier technologies), among which the most important, according to the scientific community and international organizations, are such software-oriented technologies as blockchain, Big Data Analytics (Big Data), Artificial Intelligence (AI) and cloud Computing (Cloud Computing), as well as specialized machine-oriented equipment: 3D printers, internet of Things devices (Internet of things Things, IoT), automation and robotics. Significant progress in the application of these technologies contributes to the growth of production capabilities, labor productivity, and capital return of both digital companies and enterprises of the non-digital economy while transforming their established business models and principles of generating income and expenses of companies. This makes it necessary to study the above technologies in detail from the point of view of analyzing their essence, role, and potential for use in various spheres of economic life.

Although the term "blockchain" has recently entered scientific and public use, the idea of the technology appeared in the late 1980s, namely in 1989. Lamport proposed "a model for achieving consensus on results in a network of computers, where computers or the network itself can be unreliable". In 2008, Satoshi Nakamoto proposed the concept of using a decentralized computer network to operate a P2P electronic money system. In the article "Bitcoin: a Peer-to-Peer Electronic Cash System" published on the internet, the innovator described the algorithm of functioning of the Bitcoin cryptocurrency as a completely independent electronic cash system from a single issue Center, which does not require the trust (mediation) of a third party, but relies on direct operations between the parties to the transaction, protected by cryptographic encryption.

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Introduction.

The success of the Bitcoin cryptocurrency has attracted widespread attention from scientists and business representatives to the potential of this technology. However, a well-established approach to understanding its essence was never formed. Most definitions focus on the appropriate context for using blockchain technology properties, which include characteristics such as immutability, transparency, distributed database or ledger, and the lack of a reliable intermediary (Ahmad, 2021a). In general terms, "blockchain is a technology that ensures the immutability and integrity of data and records of transactions made in the system, supported through several distributed nodes that are connected by the operation of a peer-to-peer (peer-to-peer) network" (Berman, 2019).

Noting the significant importance of blockchain technology, D. Tepscott and A. Tepscott called this technology "the second era of the internet-the Internet of values". The advent of blockchain technology has made it possible to solve the problem of double-spend (double-spend problem) and at the same time avoid third-party mediation. "For the first time in history, a digital carrier of value has appeared, thanks to which you can manage any asset-from money and music to votes and Stradivarius violins, as well as store and transmit them on an equal network in security and confidentiality. Trust is guaranteed not by intermediaries, but by cryptography, cooperation, and smart code" (Ahmad, 2021b).

Due to such properties as distribution, connectivity, and the ability to verify, blockchain provides such advantages for use in various spheres of Public Life (Oh, 2020):

- accessibility: the blockchain can be used anywhere and anytime;
- independence: users of the blockchain network do not need the services of intermediaries such as notaries, lawyers, banks, or payment systems;
- security: an entry made in the blockchain cannot be forged or deleted, because all network participants have their own identical copy of the registry;
- failure resistance: thanks to the technology of separate information storage, the loss of some digital data on a certain number of nodes will not lead to failure of the system as a whole;
- the ability to work simultaneously with a large number of users;
- data uniqueness: eliminates the possibility of data repetition;
- temporary nature of entering information: when combining information blocks, they are distributed according to the creation time;
- the anonymity of network members;
- reduction of financial and time costs of network participants;
- the openness of information about transactions with simultaneous anonymity of personal data.

Along with the existing advantages, the use of blockchain technologies also has a number of disadvantages:

- the initial level of development of the blockchain technology market, which leads to rather low volumes of information in their development and distribution;
- lack of a regulatory framework for blockchain regulation, which hinders the potential for expanding confidence in the technology;
- no option to cancel the transaction after it is confirmed;
- attackers use the anonymity of transactions, creating large criminal trading platforms.

Materials and Methods.

Despite a fairly short period of development, blockchain technologies have already passed several important stages of their development. Thus, according to the founder of the Institute of blockchain research M. Swan, networks for mining and calculating cryptocurrencies should be characterized as Blockchain 1.0 (Al Ridhawi, 2021).

The next stage, called Blockchain 2.0, is smart contracts as whole classes of computer algorithms designed to conclude and support commercial transactions and which can be automatically executed when pre-defined conditions arise (Shiraz, 2014).

The main idea of using them is to exclude the human factor from business operations in order to eliminate the possibility of fraud, errors and third – party mediation. The most likely area of application of smart contracts is the support of transactions in the framework of e-commerce. The most modern stage is Blockchain 3.0, which provides for the development of special applications that function in the areas of Public Administration, Science, Health, Education, Culture and the arts.

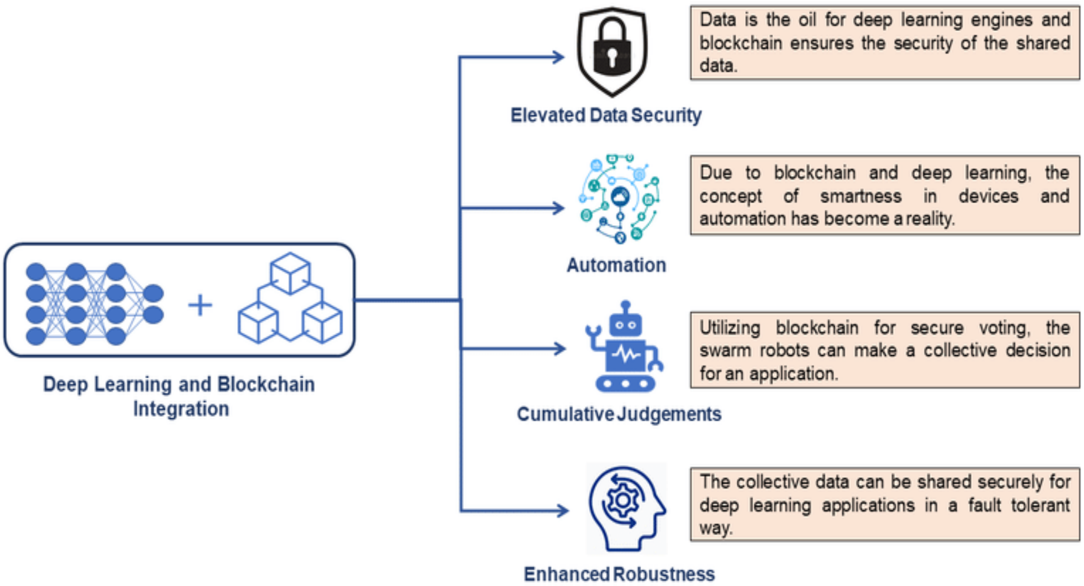

Fig. 1. Some variants of using deep learning in blockchain
Source: semanticscholar.com

Uphold finance is a platform for moving, converting, making transactions, and storing any form of money, goods, or raw materials. The service collects all banking transactions, credit, debit cards, and Bitcoin wallets in the service's internal digital wallet to simplify financial services or transactions.

Smartwallet is a platform that allows you to charge the lowest possible fee for using prepaid services (listening to music, renting a car, insurance).

Ripple is a platform that helps banks make blockchain-based international payments. This technology allows banks to transfer funds between branches around the world at low prices.

Factom data management is a platform for keeping records, recording information about the business processes of companies and NGOs in closed blockchain networks.

The Civic Digital Identity Platform allows users to register, verify personal information, and protect their credit history from fraudsters.

Identifi is a service that combines all personal network profiles and personal data into a single digital identification tool.

Grid Singularity is a decentralized information exchange platform in the industry that simplifies data analysis, testing, management of Intelligent Power Systems, and working with "green certificates".

Filament is a company that develops a node-based blockchain network of sensors that track data from electrical poles.

Electronic voting Follow My Vote is a platform for anonymous online voting that uses blockchain technology and elliptical cryptography to guarantee the accuracy and reliability of results

E-governance e-Residency is an electronic identification system in Estonia that allows holders of identification cards and digital keys to access a wide range of government, banking and other services

Rental housing by Airbnb is an application that stores a distributed register of rental housing. The platform performs reputational classification of homeowners and tenants.

Uber transport is a platform that automatically collects data from free cars and generates offers for potential rentals

Online trading Overstock is the first online store to accept cryptocurrency. It was the first to issue blockchain based bonds and preferred shares

Linq ownership is a platform (owned by NASDAQ) that allows private companies to register ownership shares digitally using blockchain technologies.

Healthcare Medicalchain is a blockchain-based service for securely storing medical records and patient information that can be used by hospitals, laboratories, and private doctors.

Charity GiveTrack is a platform for collecting and tracking charitable assistance

As of the beginning of 2019, the largest number of blockchain companies operated in the United States (345) and China (333). In general, the share of these countries in the blockchain technology market is more than 56 %. EU countries represent 15% of the Global Blockchain Ecosystem, among which the leaders are the United Kingdom (48%), Germany (8%), France (7%) and Estonia (6%).

Depending on the type of activity, the main sectors are financial services (672 firms) and Information Technology (568 firms). The first sector mainly covers companies engaged in money transfers and Transaction Processing, Investment Services, financial data management, advertising and marketing of cryptocurrencies.

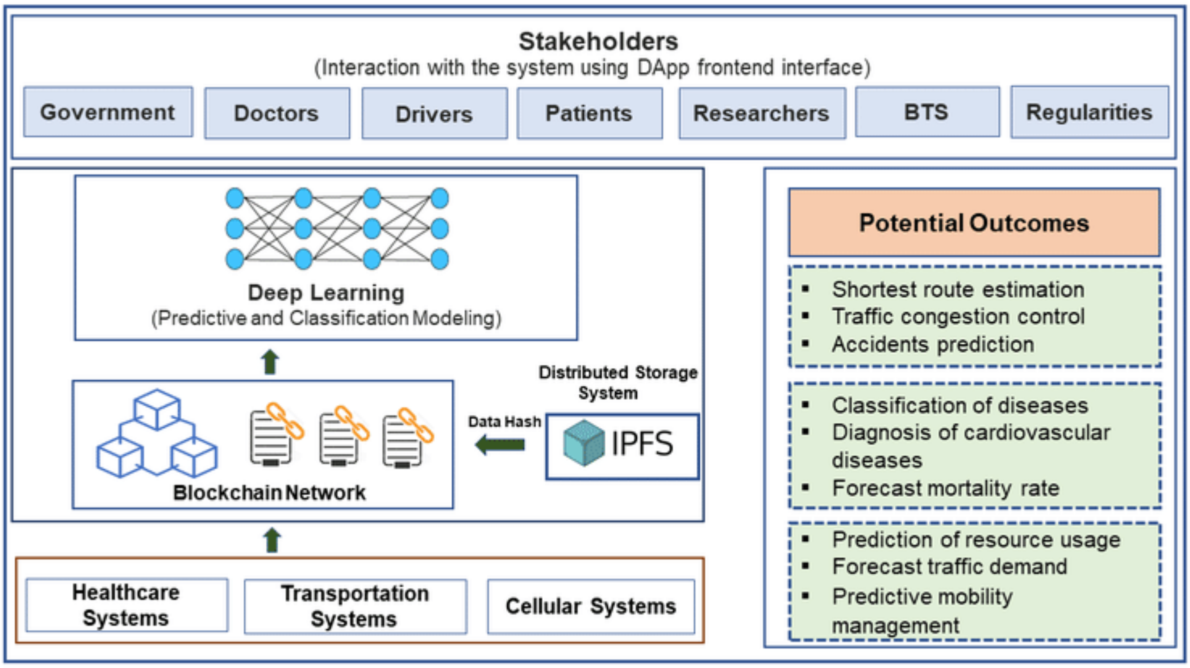

Fig. 2. Deep-learning blockchain services in government
Source: Shuja, J., et al, 2020

The second sector includes IT firms that develop software for the business community, network management applications, and databases. Also, quite numerous are blockchain startups in the consumer services sector (215 firms), which represent mass media and content sharing, shopping assistance applications, as well as educational services and entertainment.

Internet of Things.

The internet as a technology designed to provide convenient communication between people, in the era of mass connectivity and high speeds, is increasingly becoming the foundation for collecting, processing, and exchanging data between various autonomous devices, called the Internet of things. The term "Internet of Things" (from the English Internet of Things, IoT) was first proposed in 1999 by K. Ashton (K. Ashton) as a concept of widespread use of radio frequency object identification (RFID) tools for the interaction of physical objects with each other and with the external environment (Shafay, 2020).

In 2004, couple of scientists justified the concept of "Internet-0" (the prototype of the modern idea of "smart home") as a new type of network for everyday home devices (alarm clock, air conditioning, garden irrigation system, security system, lighting and heating), which interact with each other using IP protocols and provide fully automatic execution of processes depending on the algorithm of the owner of the house (turn on the coffee maker, change the lighting, regulate the air temperature, remind about taking medications) (Narayan, 2005).

In fact, there are quite a few approaches to understanding the essence of the Internet of things, but it is generally accepted that the first version of the internet was about data created by people for people, and the next version was about data created by devices.

The Internet of things can best be described as "an open and comprehensive network of intelligent objects that have the ability to organize themselves, exchange information, data and resources, react and act in situations and changes in the environment" (Ren, 2020).

The Internet of things is based on the following elements (Tan, 2021):

1. Identification tools. In general, almost any object in the physical world can become part of the Internet of things. To do this, it must have a unique access code for automatic identification on the network.

2. Measuring instruments (data entry points). The main purpose of measuring instruments is to perceive and convert information about the external environment into digital data for further transportation. Currently, the list of data entry points includes such things as geolocation and positioning devices, barcode scanners, temperature, light, humidity, vibration, pressure, motion sensors, etc.

3. Data transmission tools. Wired (power lines, fiber-optic communication lines) or wireless technologies (mobile and satellite communications, Wi-fi, Bluetooth, NFC) are used for data transmission.

4. Data Processing Tools. In our opinion, this is one of the most important elements of the Internet of things, on the power of which the value of the Internet of things as a technology depends. It was the lack of computing power that was a factor in delaying the development of IoT until the early 2010s, when powerful cloud systems with high bandwidth and the ability to quickly respond to certain situations began to appear.

5. Executing devices. These are devices that perform certain actions based on the processed information. Quite often, they are combined with sensors and sensors.

The Internet of things involves the following sequence of steps: connecting devices for data collection; collecting digital data, moving it and storing it; processing, analyzing and using data; creating new value for people by offering new products or services.

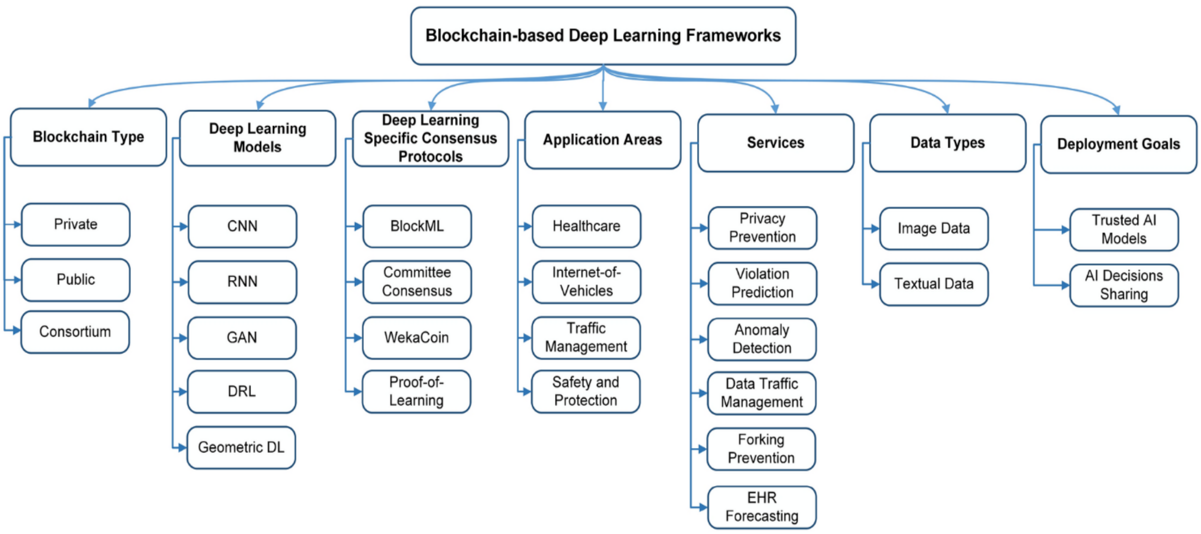

Fig. 3. A taxonomy of blockchain for deep learning frameworks
Source: Ren, W., et al, 2020

It should be noted that the introduction of practical solutions and concepts of the "Internet of Things" has become a reality today, primarily due to the wide spread of 3G and 4G wireless mobile communications, low-cost Bluetooth technologies and NFC chips, GPS geo-positioning system, the emergence of cloud computing, the development of machine-to-machine (M2M) technologies, and the transition to the IPv6 standard.

In general, the hierarchy of the Internet of things consists of:

1. Personal wearable devices (Wearables). They contain smartphones, smart watches, smart glasses, and medical devices that can track a person's location and track their various physical parameters.

2. Smart Homes. They are designed to control and enhance certain functions in the home, giving the user the value of peace of mind, comfort, efficiency, and safety. They contain smart TVs, refrigerators, flashlights, lighting and temperature sensors, and security systems.

3. Smart Industry, Smart Manufacturing, Industrial Internet, Smart Industry (Smart Industry, Smart Factory). It is part of the Internet of things, providing "fully integrated enterprise production systems that are able to respond in real time to changing production conditions, supply chain requirements, and meet customer needs" (Wang, 2010).

According to the founder of the World Economic Forum K. Schwab (K. Schwab), the " smart industry "is a radical turning point in the "Fourth Industrial Revolution". While the previous waves of the Industrial Revolution covered mechanization, mass production, and the introduction of computers and electronics, this wave "will contribute to the development of a purely machine economy" (Zheng, 2020), the achievement of which depends on three basic characteristics of the "smart industry":

- combine the power of data collected by connected devices with intelligent analytics. This will allow companies to anticipate how assets work and how they can increase the value of their product to the consumer.;
- reduce routine tasks and possible production errors;
- creation of intelligent interactive objects as a synergy effect of sensor and device networks and other digital technologies, such as cloud computing, artificial intelligence, blockchain, and virtual reality.

According to the report of the World Economic Forum, the "Industrial Internet" is likely to develop within 4 consecutive phases:

1. Improving the operational efficiency of enterprises by reducing operating costs and increasing the productivity of workers.
2. The emergence of new products and services, such as selling data to other companies.
3. The growth of the" results economy", which is based on digital platforms and ecosystems.
4. The emergence of an "autonomous attraction economy", which provides for constant monitoring of customer sentiment and optimization of the resources used.

In total, according to Statista, as of the beginning of 2020, there were more than 30 billion Internet of Things devices in the world, which is twice as much as 5 years ago.

In 2025, this area is projected to grow another 2.5 times, exceeding the level of 75 billion internet-connected devices. The active growth of connected devices will be facilitated by the mood of consumers, who already have an average of 4 devices that exchange data with cloud services at the beginning of 2020. Until 2025 the average person in the world will interact with IoT devices almost 4,900 times a day, or every 18 seconds (Hassan, 2020).

As a result, the projected global Internet of Things market, which in 2018 was estimated at 1190 billion. The United States will grow almost 6-fold by 2026 to 1.11 trillion. The largest share of this market is expected to be received by the banking and financial services sectors, as well as agriculture [11].

According to a report by the International Data Corporation (IDC), global IoT spending will exceed 1 trillion by 2022.

More than two-thirds of this amount is accounted for by seven developed countries of the world (the United States, China, Japan, Germany, South Korea, France and the United Kingdom).

Big Data.

The first mention of the term "Big Data" (Big Data) appeared in an article by the editor of the journal Nature K. Lynch (C. Lynch) " How is your data growing?"(2008) (Bach, 2018). The researcher used the term in the context of defining the problem of managing the growing amount of data in research projects and grants.

The main technical problem of that time was the ability to store large amounts of data and computer capabilities for their efficient analysis.

The first commercial companies to face the need to manage growing amounts of data were representatives of the internet businesses of Google, Amazon, Yahoo, Facebook, and Alibaba.

Sensing the potential to monetize their customers ' online activity data, they have invested heavily in data storage and analysis technologies. The result was the emergence and widespread use of "cloud technologies" and virtual file systems that distributed data and workloads across multiple servers. This has significantly reduced the cost of data storage and processing and helped companies move from a managed infrastructure to a service-based approach.

Subsequently, the concept of big data covered several aspects in one term, ranging from the technological base to a set of economic benefits, which were manifested in a reduction in the cost of storing and processing data and a corresponding increase in business investment costs for their active use. In this context, the definition of the "Networked European software and Services Initiative" is quite successful, according to which "big data is a term that includes the use of methods for collecting, processing, analyzing and visualizing potentially large data sets in a reasonable time frame that is not available for standard IT technologies" (Berman, 2019).

The value of big data is formed by taking into account the needs of various sectors of the economy and involves passing the appropriate stages: data collection, analysis, storage and use.

Key sources of big data:

- information from the internet: social networks, blogs, mass media, forums, websites;
- readings of various devices: IoT sensors, audio and video recorders, smart gadgets, smartphones, cellular communications, etc.;
- corporate information: archives, internal information of enterprises, etc.

In general, BigData analysis, which originated in order to improve the effectiveness of management decisions, is now turning into a way to create "top-line value", taking into account the interests of both the company that produces the product or service, as well as partner companies, customers, government and non-profit organizations. Focus on value creation, which is based on big data analysis, according to analysts of the World Economic Forum D. Ohalloren (D. O'halloran) and F. Souza (F. D'souza), allows companies to gain competitive advantages by (Shuja, 2020):

- create a new pool of values that will promote new revenue streams, products and services for a wider range of stakeholders;
- the emergence of new business models that will be widely based on joint models of partnerships and ecosystems;
- expanding the experience of all interested parties in the business, which is based on Broad personalization and new contexts for using the product or service;
- making decisions regarding the development of the company, its products and services.

A survey of 4000 companies conducted in 2017 by Shuja (Shuja, 2021) showed that the most active users of big data are companies from telecommunications (87%), financial services (76 %) and healthcare (58%).

For example, financial institutions use big data to personalize customer offers (93%), price, underwriting and risk management (92%), detect fraud and potential threats (86%), and monitor potential losses and customer claims (76 %) (Tan, 2021). In the corporate sector, BigData is used to solve the following tasks: forecasting the market situation, marketing and optimization of sales of goods and services, improving product characteristics, making managerial decisions, setting up logistics, increasing labor productivity, monitoring the state of fixed assets.

Note that the popularity of big data is confirmed by the revenue dynamics of companies that provide business intelligence services. Their volume at the beginning of 2020 reached 208 billion USD.

Cloud Technologies.

The trend of recent years is the rapid growth of cloud services for storing big data. In 2019, cloud services surpassed stationary data warehouses for the first time in terms of revenue from data storage of companies.

The leaders in terms of revenue generated in the cloud technology market are companies from the United States: Amazon Web Services (33 %), Microsoft Azure (13 %), IBM Cloud (8 %), Google Cloud (6 %). Among companies in the real sector of the economy, the dominance of these companies is even greater. So, 68% of the world's companies use Amazon Web Services cloud services, 58 % – Microsoft Azure, 19 % – Google Cloud, 15 % – IBM Cloud.

The surge in activity of companies in the use of cloud technologies in various spheres of life is due to their indisputable advantages, including (Zheng, 2020):

- ability to configure the cloud configuration yourself;
- universal network access features;
- ability to connect a large number of people together to use a single amount of numerical resources;
- providing remote access to data using any devices connected to the internet;

- the ability to reduce the cost of hardware, software and maintenance of IT systems by subscribing to cloud services;

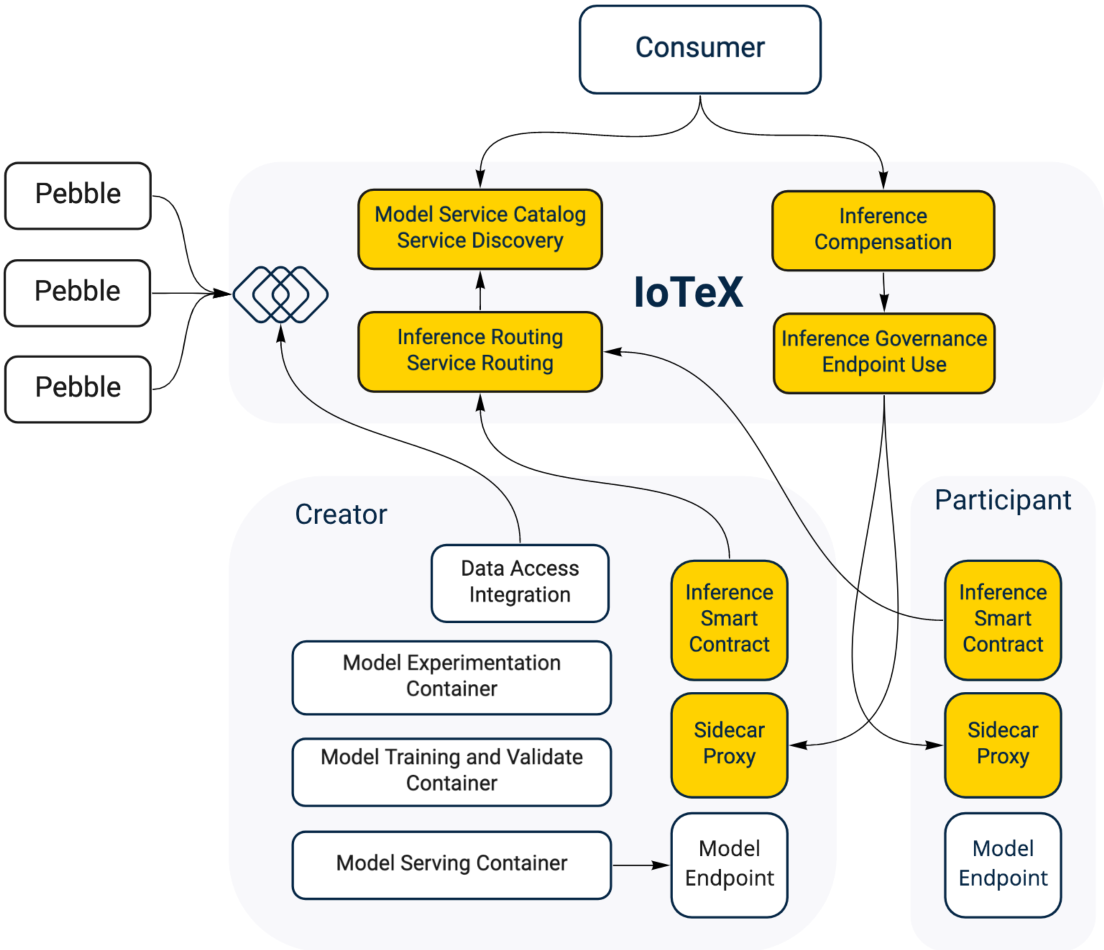

Fig. 4. IoTeX blockchain services with ML
Source: iotex.com

- greater technological capacity for data storage, analysis and processing at a lower cost;
- easy scaling of IT systems with growing business needs;
- cryptographic security, data security and integrity.

In general, three models of providing cloud services have been formed in the World (Brown, 2020):

- Infrastructure as a Service (IaaS). A model that allows you to flexibly configure the company's cloud infrastructure to meet its needs. The market leader is Amazon.
- Platform as a service (PaaS). A model that involves managing data using application programs. For Example: Google Drive.
- Software as a service (SaaS). A model that provides customers with access to a subscription to use software products. Examples are Google Doc and Microsoft Office 365.
– Everything as a Service (EAAs). A model that combines elements of infrastructure and platform solutions from one or more vendors assembled within the same service in cloud applications.

According to a study by Gartner, the global cloud services market will reach more than 380 billion USD in 2020 (Hassan, 2020).

Of these, 39.4%, or more than 150 billion USD. Cloud advertising services will account for 19.5%, or more than 75 billion USD. Cloud-based application software services and 18.5%, or more than 7 71 billion USD - cloud services of the system infrastructure.

Artificial Intelligence.

In the context of the development of modern digital technologies, we also note the role of "Artificial intelligence" as a technology that, according to Forbes magazine, is "the most transformative among modern technologies" (Ayyoubzadeh, 2020).

In general, the process of artificial intelligence includes the following stages: training (processing information samples), forecasting (based on information samples, future events and decisions are predicted) and self-correction (continuous improvement of processing and decision-making algorithms).

We also note that today the artificial intelligence ecosystem covers the following components (Shuja, 2021):

- machine learning, which involves developing new computer algorithms and improving existing ones for analyzing complex data, recognizing patterns, and predicting;

- Robotics, which is associated with the development and training of robots (Bots) to interact with people and Svi-Tom in accordance with life situations and a certain degree of self-awareness. Modern robots can fly airplanes, conduct legal cases, create journalistic texts, and perform medical operations;

- artificial neural networks related to the development of algorithms for simulating the ways of thinking of the human brain. They are most often used to determine a specific object, its movement, or other characteristics.

Even though the concept of artificial intelligence still looks futuristic, at least its basic elements are already used by many companies in different sectors of the economy.

In particular, Alibaba uses artificial intelligence to predict demand for goods and generate personal customer offers; Alphabet – to assess the behavior of people on the network, develop an autonomous car control system, recognize voice commands; Amazon - for the work of the Alexa voice assistant and personal recommendations to customers; Apple – for the work of the Siri voice assistant; Facebook-for automatic understanding of the content and emotional component of posts of participants of the social network (Shuja, 2021).

In the financial sector, artificial intelligence is used to automate customer creditworthiness assessment, effective risk management, automated trading on the stock exchange, virtual assistants, robo-advisors, and fraud security systems. For example, ZestFinance is a developer of Zest automated machine Learning (ZAML) underwriting platforms.

It helps credit institutions evaluate borrowers who do not have a credit history or their credit score is low. A successful example of using the platform is the reduction of annual expenses by an average of 23% for car loans. The DataRobot app helps financial institutions build accurate predictive models of potential credit card fraud and estimates the probability of a customer defaulting.

The Kavout program, using machine learning and quantitative analysis to process huge sets of unstructured data, allows you to develop models for the development of the situation in financial markets in real time. Kasisto, a developer of an artificial intelligence conversational platform, uses chatbots to improve the customer experience in the financial industry by making recommendations for performing simple financial transactions.

Nina, a web assistant at Swedbank, made an average of 30 thousand conversations per month in the first year of its launch, processing more than 350 different customer questions and answers.

Abe AI's Virtual Assistant integrates with Google Home, SMS, Facebook, Amazon Alexa, Slack, and other user applications and provides services for personal financial management, budgeting, saving and tracking expenses, and conversational banking.

Similarly, the Trim app, by joining the client's bank accounts, forms a personal cost-saving strategy, including automatically closing subscriptions to various services, searching for the best insurance offers or profitable investments (Shafay, 2020).

In general, as of 2017 84.2% of companies or departments of banks engaged in payments and card issuance used the advantages of artificial intelligence in their activities (Ren, 2020).

Potential opportunities for digital technologies to ensure financial security. Analyzing the essence and capabilities of other digital technologies (Big Data, Artificial Intelligence, Machine Learning, Blockchain) and financial innovations based on them, we note that they have a more pronounced positive potential for creating tools to neutralize threats to financial security.

According to experts, the monetary policy of developed countries of the world is approaching the limit of its effectiveness (Ren, 2020), which indicates the need for new approaches, relying on new sources of unstructured data – social networks, traditional information systems, the Internet of things.

So, Big Data technology allows you to track the state of the economy in real time and measure inflation according to a certain range of indicators, based, for example, on prices in online stores, labor market dynamics, real estate, business expectations, etc.), which improves the quality of analysis and forecasting, creates the ability to identify problems in advance and gives monetary policy greater flexibility and stability.

Big Data technology can be useful in managing foreign exchange reserves and determining their optimal volume, predicting currency risks and ensuring the stability of the national currency. As for the prodential policy, the use of Big Data should be expected to have effects in ensuring financial stability, stress testing, combating money laundering and terrorist financing, uncovering fraudulent schemes, and so on. At the level of a financial intermediary, Big Data technology is important for determining the client's solvency, identifying the main channels of transactions, segmenting and personifying the offer of products and services, managing financial resources and Credit Debt, Risk Assessment, and crisis management, meeting regulatory requirements and reporting, and so on. In other words, such approaches are a qualitative addition to traditional ones, providing promptly complete and detailed information that improves operational efficiency, ensuring financial stability and financial and credit security.

Along with this, significant amounts of data require modern methods, including artificial intelligence (AI) and machine learning (ML) technologies, to turn them into knowledge.

Among the areas of use of AI and ML by central banks, it is worth noting:

1) improvement of forecasting and analytical tools;

2) market research on central bank transparency and behavioral trends;

3) Asset Management-identifying the dynamics of changes in the exchange rate and prices of securities, precious metals to develop trading models, tracking the market reaction to central bank interest rates;

4) market analysis – identifying changes in asset prices to build strategies for their distribution, ensuring a balance between risks and returns;

5) Government Securities Management – identifying the dynamics of changes to develop trading models;

6) risk management – assessing financial stability;

7) user support via chatbots; and the like.

For commercial banks and other market participants, it is important to correctly understand the statements of central banks as signals of their future policies. In this direction, the AI-based Nordea Research Center developed the Hawk-o-Meter tool in 2019 to predict the monetary policy of the Fed, ECB, Bank of Great Britain, and Sweden regarding the increase/decrease in interest rates. The results of this forecast are published on Twitter and Bloomberg.

The proliferation of AI and ML in commercial banks is associated with solving problems of managing financial, operational and credit risks, as well as for automating support services through chatbots to improve the quality of Service and protect against reputational risks by reducing waiting times and increasing the number of processed requests, constant self-learning based on ML.

This allows you to increase productivity and reduce the cost of important resources that will be used to create new value in the future.

Regarding the potential of using digital technologies (Big Data, AI, ML, blockchain, Internet of things) in the field of Public Finance Management and improving budget security, we note that such technologies will become an effective tool for macroeconomic and budget forecasting, planning and analysis of budget execution, assessing the impact of draft regulatory and legislative acts on the budget, maintaining state registers, managing state assets and public investments, improving the e-procurement system, etc (Oh, 2020). All this will generally reduce budget security risks.

An example of the use of digital technologies in the field of taxation is the AI Economist project of Salesforce, which performs simulation modeling of the ideal tax system that all countries of the world strive to build.

These technologies can also increase the efficiency of tax revenue administration and counteraction to abuse and violations, more accurately predict and calculate the tax base, improve internal control and audit of taxation, expand electronic services for taxpayers, and so on.

RegTech technology also helps to mitigate financial security risks to improve the efficiency of compliance with regulatory requirements and SupTech to provide effective ways to identify and assess risks, collect and analyze data.

The digital economy, the processes of digitalization and the introduction of financial innovations based on digital technologies are an irreversible process of evolutionary development. In the context of the digital economy and the growing importance of information and technological factors for economic development, the threat system is being transformed.

At the same time, the specifics of impacts on financial security and its individual structural components are changing, the Prevention of the destructive effects of which requires the development and implementation of practical measures to improve the mechanisms for ensuring it.

Transformational changes in the business economic environment lead to the need for a dynamic response to Digital Trends, the formation of the ability to introduce financial innovations based on digital technologies, monitoring financial security to assess the security, stability and stability of the financial system, the sufficiency of economic development potential for market and social inclusion.

Conclusions.

Thus, blockchain, the Internet of things, and big data together with cloud technologies and artificial intelligence contribute to better analysis, processing, and use of digital information, which provides new opportunities for companies to improve the efficiency of their activities by offering new more personalized products and services. If applied systematically, these technologies can become one of the most influential drivers of digital economy growth in different countries of the world, becoming the basis for the emergence of derivative technologies. In general, the analysis of the experience of using these technologies shows their significant potential for the development of modern society, which can contribute to the formation and development of the digital economy in the coming years.

REFERENCES

1. Ahmad, R.W., Hasan, H., Jayaraman, R., Salah, K., Omar, M.: Blockchain applications and architectures for port operations and logistics management. Res. Transp. Business Manag. (2021a). https://doi.org/10.1016/j.rtbm.2021.100620
2. Ahmad, R.W., Salah, K., Jayaraman, R., Yaqoob, I., Ellahham, S., Omar, M.: The role of blockchain technology in telehealth and telemedicine. Int. J. Med. Inf. 148, 104399 (2021b)
3. Al Ridhawi, I., Aloqaily, M., Jararweh, Y.: An incentive-based mechanism for volunteer computing using blockchain. ACM Trans. Internet Technol. 21(4), 1–22 (2021)
4. Ayyoubzadeh, S.M., Ayyoubzadeh, S.M., Zahedi, H., Ahmadi, M., Kalhori, S.R.N.: Predicting COVID-19 incidence through analysis of google trends data in Iran: data mining and deep learning pilot study. JMIR Public Health Surv. 6(2), e18828 (2020)
5. Bach, L.M., Mihaljevic, B., Zagar, M.: Comparative analysis of blockchain consensus algorithms. In: 41st International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO). IEEE 2018, pp. 1545–1550 (2018)
6. Berman, D.S., Buczak, A.L., Chavis, J.S., Corbett, C.L.: A survey of Deep learning methods for cyber security. Information 10(4), 122 (2019)
7. Brown, T.B., Mann, B., Ryder, N., Subbiah, M., Kaplan, J., Dhariwal, P., Neelakantan, A., Shyam, P., Sastry, G., Askell A., et al.: Language models are few-shot learners. arXiv preprint arXiv:2005.14165, 2020
8. Hassan, T., Shafay, M., Akçay, S., Khan, S., Bennamoun, M., Damiani, E., Werghi, N.: Meta-transfer learning driven tensor-shot detector for the autonomous localization and recognition of concealed baggage threats, Nov 2020. https://www.mdpi.com/1424-8220/20/22/6450
9. Lawrence, S., Giles, C.L.: Overfitting and Neural networks: conjugate gradient and backpropagation. In: Proceedings of the IEEE-INNS-ENNS International Joint Conference on Neural Networks. IJCNN 2000. Neural Computing: New Challenges and Perspectives for the New Millenniu, vol. 1. IEEE, 2000, pp. 114–119
10. Narayan, S., Tagliarini, G.: An analysis of underfitting in MLP networks. In: Proceedings. 2005 IEEE International Joint Conference on Neural Networks, 2005., vol. 2. IEEE, 2005, pp. 984–988
11. Oh, Y., Park, S., Ye, J.C.: Deep learning COVID-19 features on CXR using limited training data sets. IEEE Trans. Med. imaging 39(8), 2688–2700 (2020)
12. Ren, W., Hu, J., Zhu, T., Ren, Y., Choo, K.-K.R.: A flexible method to defend against computationally resourceful miners in blockchain Proof-of-work. Inf. Sci. 507, 161–171 (2020)
13. Shafay, M., Hassan, T., Velayudhan, D., Damiani, E., Werghi, N.: Deep fusion driven semantic segmentation for the automatic recognition of concealed contraband items. In: SoCPaR, 2020, pp. 550–559

14. Shiraz, M., Gani, A., Ahmad, R.W., Shah, S.A.A., Karim, A., Rahman, Z.A.: A lightweight distributed framework for computational offloading in mobile cloud computing. PLoS ONE 9(8), e102270-9 (2014)
15. Shuja, J., Alanazi, E., Alasmary, W., Alashaikh, A.: COVID-19 open source data sets: a comprehensive survey. Appl. Intell. 51(3), 1296–1325 (2021)
16. Shuja, J., Bilal, K., Alasmary, W., Sinky, H., Alanazi, E.: Applying machine learning techniques for caching in edge networks: a comprehensive survey, arXiv preprint arXiv:2006.16864, 2020
17. Tan, L., Xiao, H., Yu, K., Aloqaily, M., Jararweh, Y.: A blockchain-empowered crowdsourcing system for 5g-enabled smart cities. Comput. Stand. Interfaces 76, 103517 (2021)
18. Wang, L., Von Laszewski, G., Younge, A., He, X., Kunze, M., Tao, J., Fu, C.: Cloud computing: a perspective study. New Gen. Comput. 28(2), 137–146 (2010)
19. Zheng, Z., Xie, S., Dai, H.-N., Chen, W., Chen, X., Weng, J., Imran, M.: An overview on smart contracts: Challenges, advances and platforms. Fut. Gen. Comput. Syst. 105, 475–491 (2020)