Digital Transformation and Blockchain

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Introduction

Digitization has emerged when data has been digitized and processed by computers. Legner et al. (2017) stated that digital technologies have spread in three waves in recent years, transforming business and social life. Legner et al. (2017) exemplified the first wave as the reduction of paper as a result of the use of computers in routine work and the provision of automation. The second wave is the global spread of the internet and the emergence of new developments such as e-commerce. The third wave is expressed as the experience of businesses and society on developments in storage capacity, internet bandwidth, and processing power. With the development and spread of the Internet and information technologies, a period called Industry 4.0 has begun to be experienced. In this period, the emergence of innovative business models, new business processes, and smart products and services that emerged as a result of the development of digital technologies can be called "digital transformation".

Similar definitions of digital transformation have been made in literature and studies published by institutions: In the report published by the OECD, digital transformation is expressed as the economic and social impact of digitization (OECD, 2018). The European Commission defined digital transformation as the creation of smart products and innovative business models as a result of the integration of physical and digital systems with the development of digital technologies (Advanced Technologies | Internal Market, Industry, Entrepreneurship and SMEs, n.d.). Fitzgerald et al. (2014) define digital transformation as making the necessary structural changes and developing new business models by using technologies such as social media, mobile applications, and data mining in order to gain an advantage in the market and meet customer demands. Young and Rogers (2019) define digital transformation as a technology-driven change process derived from accessible connections, data, and decision-making processes. From the definitions made, it is understood that digital transformation covers not only the developments in digital technologies but also the impact of these developments on institutions.

The rapidly developing and widespread internet and information technologies create a volatile, complex and uncertain environment for institutions. Therefore, it is very important to understand what changes these technologies can bring to business models, business processes, and organizational structures (Matt et al., 2016). The most common digital transformation goals in the literature are; increasing flexibility, developing customer-oriented processes, and reducing costs (Hofmann & Rusch, 2017). Today, most of the shopping and financial transactions are carried out over the internet and the number of these transactions is increasing. An environment of trust is essential in such financial businesses managed on the Internet and in applications involving data storage, data sharing, and data verification. Third-party companies and/or central authorities are generally used to create this trusting environment. This situation causes important information for institutions and individuals to be made available to third parties. This poses a risk to information security and privacy. In addition, a malfunction in third-party systems will cause the entire system to become inoperable at once. Working with central authorities or using third-party applications to allocate an environment of trust between users and institutions brings both a serious financial burden and external dependency. Thanks to its distributed, transparent, immutable, and secure structure, blockchain technology, which has become widespread recently, can be recommended as a suitable option for solving these problems. With blockchain technology, the following examples can explain why it is suitable for solving the mentioned problems: In the past, several efforts have been made toward the creation of a worldwide valid digital currency. However, these studies have not been successful due to reasons such as double spending or the need for a central authority. Blockchain technology was first introduced in 2008 in an article published by a person or group named Satoshi Nakamoto (Nakamato, 2008). Blockchain technology, thanks to its distributed and transparent structure, enables data sharing between stakeholders/nodes in an encrypted and secure manner without a need for central authority. In the blockchain, data is kept in distributed ledgers. Recording data in distributed ledgers can only be realized as a result of the consensus of the stakeholders in the blockchain network. In the blockchain network, data is recorded with the consent of the stakeholders, and the record is stored by all stakeholders in a distributed and transparent manner. In this way, data security and integrity are ensured and historical data deletion or modification can be prevented. Blockchain, first known as the technology behind digital currencies, has been leading innovative solutions in many fields such as finance, supply chain, health, public services, and education in recent years. It is thought that blockchain, which is rapidly developing and becoming widespread as a new technology, will also play an important role in the digital transformation process. Since blockchain contains technologies with high potential such as smart contracts, consensus mechanisms, and encryption techniques, it is no doubt that there will be many use cases in many different fields in the future and it will play an important role in digital transformation. In the following chapters, examples and applications for the content and usage of the blockchain are mentioned.

Blockchain

Many definitions of blockchain have been made in the literature. Nakamoto, who introduced the concept of blockchain for the first time, defined it as a distributed ledger where every record is stored and shared in a distributed structure by the stakeholders in the network. Li et al. (2021), blockchain is an emerging technology that encompasses many computer sciences such as cryptography-based digital signatures and distributed consensus mechanisms.

Reyna et al. (2018) defined the blockchain as a secure data warehouse where data is stored in a distributed, transparent and immutable structure as a result of an agreement reached by the stakeholders. According to Glaser (2017), a blockchain is a database where participants keep records of their assets publicly and under pseudonyms without the need for an intermediary or central authority. Johar et al. (2021) defined blockchain as a distributed ledger technology secured by cryptography in response to the trust problem that users have experienced for a long time. Lewis (2018) has shown that, unlike traditional databases, transactions such as adding and verifying records in blockchain are done by stakeholders with consensus mechanisms on the P2P network. The features that distinguish blockchain technology from other data storage technologies can be listed as follows (Gatteschi et al., 2018; Yavuz, 2019):

0. A copy of the record is saved by all participants in the network. By keeping the record transparent in this way, data loss and data destruction are prevented.

i. It enables the development of distributed and automated applications in different fields, thanks to new technologies such as smart contracts and digital signatures

ii. Thanks to digital signature and consensus mechanisms, stakeholders are ensured to trust each other without the need for a central authority.

iii. Since it works in a distributed structure without a central authority, it cannot be controlled or shutdown.

One of the most important services offered by blockchain technology is smart contracts. It is thought that smart contracts can replace classical contracts by operating within the decentralized and predetermined rules on the blockchain network (Reyna et al., 2018). Thanks to smart contracts, banks, notaries, and similar third parties are eliminated; therefore, significant advantages are provided in terms of cost, speed, and security. It is thought that smart contracts, which are being used in many areas today, have great potential and will become more popular and widespread in the future (Luu et al., 2016). The development of the blockchain from its emergence to the present is evaluated in three phases (Burgess, 2015; Swan, 2015; Zhao et al., 2016): The first of these is the Blockchain 1.0 phase, where the blockchain is recognized as the technology that forms the infrastructure of Bitcoin and other digital currencies. The period when smart contracts and financial applications are used is called Blockchain 2.0. In recent years, widely use of blockchain in varied areas such as health, agriculture, education, public administration, and IoT is called blockchain 3.0. In the period called Blockchain 1.0, the blockchain used in the infrastructure of digital currencies was transparent and open to everyone's participation without any restrictions. In this type of blockchain in which institutions and individuals can participate in data adding or mining activities without any control, the mechanism is called a "Public Blockchain" (Puthal et al., 2018). In the blockchain 2.0 and blockchain 3.0 phases, blockchain technology began to become widespread and better understood. In these periods, blockchain has been used in different fields by institutions, companies and researchers apart from digital currencies. Most of the blockchain systems used in these studies have been implemented in such a way that authorized participants can exchange data within their authority, rather than making it accessible to everyone. Blockchain systems managed by an individual or a group that allow data sharing between individuals in one or several organizations are called as "Private Blockchain". Blockchain structures in which the authority of a single person or group in private blockchain systems is transferred to predetermined participants in the network are called "Consortium Blockchain".

In such blockchain networks, the consortium decides whether the network is public or limited, and who will join the network, and what privileges the participants will have, such as reading and writing (Puthal et al., 2018). When the phases of blockchain are examined, it can result that like the rapid technological developments in other fields, the blockchain has been developed rapidly to respond to the newly emerging needs that have arisen in its short history; and new technologies that will adapt to these developments have been put to work. However, it should not be overlooked that it also contributes to the emergence of new business areas (blockchain / Web 3.0 developer, etc.).

In addition to these, although blockchain has great potential as a new technology, some difficulties may be experienced in cases of widespread use. Some of these are as follows: Blockchain systems that use "proof of work" as a consensus protocol consume a lot of energy and require a high amount of information resource investment. For example, as of 2021, the amount of energy consumed for the Bitcoin blockchain, which relies on the "proof of work" protocol, is more than the energy consumption of many countries (Bitcoin Consumes "more Electricity than Argentina"- BBC News, n.d.). At the same time, as a result of the excessive demand for many computer parts such as the video card used in Bitcoin mining, the prices of these parts have increased greatly. Moreover, storing and verifying all the data in the blockchain by all participants can lead to situations where performance is insufficient under heavy processing load, prolonging the processing times and thus loss of time. Transactions made by users in blockchain systems are shared transparently in an encrypted manner. As a result of the analysis of this publicly shared data, it is possible to access the real identities of the accounts or the real identities of the users (Meiklejohn et al., 2013). Moreover, in addition to the difficulties encountered in applications that have been implemented and become widespread, new features may be needed in parallel with newly developing technologies. Blockchain continues to develop as new technology and many studies are being carried out by researchers and companies to overcome the aforementioned difficulties. The following sections include applications of blockchain in prominent sectors. It is thought that these applications will contribute to the formation of different new application ideas and their transformation into practice over time.

Blockchain Based Digital Transformation Applications

The blockchain, which first entered our lives with digital currencies, has pioneered many solutions that make life easier in the financial sector. In recent years, the number of blockchain-based innovative applications has been increasing. The smart contracts in the blockchain guarantee that the parties comply with the agreements and rules. Consensus mechanisms ensure that every record added to the blockchain is approved by the stakeholders. With these services offered, the blockchain not only allows the business to be carried out securely but also allows the stakeholders to trust each other (Javaid et al., 2021). Thanks to the processing of data obtained from sensors and machines, important information may emerge, and significant gains can be achieved. With the use of IoT devices, which have developed and become widespread in recent years, together with the blockchain, transparent traceability can be ensured by creating an environment of trust between the stakeholders, and thus fraud can be prevented. These developments, which offer significant advantages for production, supply, retailing sectors, and consumers, pave the way for a new digital transformation. Blockchain-based solution proposals in different fields and applications that have been implemented are given below.

Applications for Supply Chain

Today, storing data about processes such as production, food processing, and distribution in traditional supply chains, as paper-based records or in special databases causes serious difficulties. Some of them are as follows (Lin et al., 2020):

- Data stored in private and central databases can be manipulated, causing trust issues among stakeholders.
- The entire supply chain can become inoperable after a single point of failure.
- Central databases vulnerable to hacker attacks can be destroyed or confidential data may be stolen.
- High costs may arise if third-party support is sought for data validation and monitoring.

In the past years, studies involving distributed databases and cryptography have been carried out to overcome these problems. Among these, blockchain stands out with the services it offers in response to trust issues (Lin et al., 2020).

In recent years, many studies containing blockchain-based supply chain application proposals have been published by researchers. Shadid et al. (2020) proposed an application for the transparent, distributed, and secure management of all transactions from the production stage to the customer with smart contracts on the blockchain. In this study, as in many other similar studies, it has been proposed to keep data such as sensor information and production pictures encrypted on cloud servers and to store the key information necessary for accessing this data on the blockchain in order to alleviate the data load on the blockchain. In the proposed system, manufacturers, carriers, and retailers participate in the blockchain network as participants. In this study, the exchanges and payments between the participants are made through smart contracts. In addition, participants can give evaluation points and write comments about each other. This evaluation information held on the blockchain is presented as a benchmark for future purchases. In this study, the proposed application was simulated, and the results were also included.

In addition to the theoretical studies in the literature, the number of real-life applications is increasing. IBM offers its clients blockchain services for use in many areas such as supply chain, smart agriculture, vaccine applications, and authentication (Blockchain for Supply Chain - IBM Blockchain | IBM, n.d.). After the emergence of the food scandal in the past years, Walmart, one of the largest supermarket chains in the world, managed the pork trade in China and the mango trade in America in 2016, from production to the customer, using the Hyperledger-based blockchain system offered by IBM (Kamath, 2018). An application called Provenance has been developed in Indonesia in collaboration with NGO Humanity United and International Pole and Line Foundation (From Shore to Plate: Tracking Tuna on the Blockchain | Provenance, n.d.). With this application, customers can inquire where the fish was caught, and which stages it was placed on the shelf, through the QR code and RFID information placed on the tuna. In France, a tracking system called Ambrosus has been developed to track olives from fields to warehouses, and from there to the packaging factory and retailer (Ambrosus.Io, n.d.). Unlike existing tracking systems, Ambrosus provides tracking of olives with RFID technology starting from production. The exchange of olives is also done by smart contracts on the Ethereum network. Te-Food application has been developed to follow the process of pork from production to the customer (TE-FOOD, n.d.). With this application, the farmer registers the pigs to the blockchain via her smartphone with RFID and QR codes.

Then, it is ensured that the trucks used for transportation can also be tracked with RFID. The slaughter of pigs in trucks arriving at the slaughterhouse is monitored by veterinarians and identified with a QR code. In this solution, blockchain services are also used for exchanges between companies and evaluation comments for the products made by the user. The app was launched in South Vietnam in early 2017 and more than 6,000 companies have been trained to use the app. It has been stated that 25 thousand chickens and 2 million eggs are monitored daily in Te-Food, which has been used for chicken and egg tracking since September 2017.

Applications for Healthcare

Today, the use and sharing of electronic health records (EHR) of patients have become an important issue. It is thought that sharing EHRs will make an important contribution to increasing the accuracy of diagnosis of diseases and improving the quality of health services. Today, most the EHRs are stored in traditional databases which puts data security and patient privacy at risk. The World Health Organization defines EHRs as a valuable and protected asset of the patient (Michelsen et al., 2015). For this reason, consent from the patients as the owner of the data is required for the sharing and use of EHRs. Today, in parallel with the rapid development of information technologies, attack methods that threaten data integrity and privacy are also being renewed. It would be right to follow new technologies and develop appropriate solutions as a precaution against these threats. Blockchain technology with its features and opportunities, allows EHRs to be shared in an encrypted, distributed and transparent manner.

Many blockchain-based studies have been conducted in the field of health regarding secure data sharing and the protection of patient privacy. BPDS application suggested by Liu et al. (2018) is one of them. In this study, EMRs, which require large disk capacity, are stored in an encrypted cloud environment, and the key information required for viewing these data is kept distributed on the private blockchain. In BPDS, public and private key information and blockchain accounts of all user groups such as hospitals, doctors, patients, and pharmaceutical companies are created. In this study, healthcare organizations, patients, and healthcare professionals can request patients' EMRs for better treatment or medical research. Patients also approve the use of requested EMRs through smart contracts. In this way, information such as the request for each data, approval for sharing, and usage history can be stored on the blockchain.

Nguyen, et al. (2019) presented a blockchain-based solution for mobile cloud-based e-health systems, which are frequently used. In this study, an android application has been developed in which EMRs recorded in distributed Amazon cloud services are managed with smart contracts on the Ethereum network. With this service, patients are authenticated through mobile applications and smart contracts. It is ensured that doctors can access EHRs, whose key information is stored in the blockchain and transferred to the cloud environment, with authentication. Thus, the data such as who accessed which EHRs and when are kept in the blockchain. When the experimental results of the developed application are analyzed, it is stated that data management and sharing in the mobile cloud environment is provided with high performance and security.

In addition to the blockchain-based health application proposals detailed above, the number of implemented, real-life applications is increasing. A few of them are as follows; The application named MedRec, managed by MIT, provides the storage of EHRs and secure access to these data by the requesting healthcare institutions (Azaria et al., 2016).

With MedRec, patients can allow their EHRs to be used anonymously in medical research. MedicalChain is a blockchain-based platform (Medicalchain, 2022) that protects patients' identities and EHRs with advanced technology. MedicalChain also has a payment system that allows patients to pay for virtual doctor appointments using a digital currency called MedTokens. The SimplyVital Health platform is built on blockchain technology that empowers healthcare providers and patients to access, share, and even migrate EHRs (SimplyVital Health | Health/Medical | F6S Profile, n.d.).

Applications for Finance

The awareness of blockchain started with digital currencies for the first time, and today, many digital currencies are widely used in the financial sector as both payment tools and investment tools. Apart from digital currency applications, there are many blockchain solutions in finance. One of these is the B3i application, which allows the five largest insurance companies in Europe to store and share customer information on the blockchain (B3i - The Blockchain Insurance Industry Initiative, n.d.). BitGive (About Us | BitGive Foundation, n.d.) Thanks to blockchain-based donation and fundraising applications such as CAF (Charities Aid Foundation (CAF) | We Make Giving Count, n.d.), payments and expenditures can be monitored transparently. Thanks to its transparent and immutable structure, blockchain plays an important role in the digital transformation of institutions such as donations and aid organizations and foundations.

Applications for Public Services

One of the areas where blockchain-based solutions are most applied is the field of public services. In the OECD report published in 2018, it is stated that as of March 2018, 202 blockchain-based public service initiatives were launched in 45 countries (Blockchain and Its Use in the Public Sector, 2018). In Estonia, which is one of the leading countries in applying current technologies, a system that allows data such as identity information, health records, and tax payments of citizens to be stored and shared digitally on the blockchain has been implemented (E-Estonia — We Have Built a Digital Society and so Can You, n.d.). Necessary legal arrangements have been made for this digital transformation in Estonia. Due to slow and inefficient interbank money transfers, the development of an application called Project Ubin, which will enable money transfers between the Central Bank and banks to be made over the blockchain, has been started by the Singapore Money Management Authority (Project Ubin, n.d.). In 2018, a blockchain-based application called Voatz was used in the US state of Virginia so that citizens outside the country could vote in the senate elections in the countries where they reside (West Virginians Abroad in 29 Countries Have Voted by Mobile Device, in the Biggest Blockchain-Based Voting Test Ever- The Washington Post, n.d.). The Digital Turkish Lira R&D Project was initiated in Turkiye with a cooperation platform established between the Central Bank, Aselsan, Havelsan, and Tübitak-Bilgem (TCMB-Central Bank Press Release on the Digital Turkish Lira R&D Project (2021-40), 2021). In this project, studies are carried out on the use of distributed structures in payment systems, instant payment systems, and integration processes with existing systems in the blockchain network.

Applications for Education

In the field of education, where data security, data validation, and transparency are very important, blockchain-based suggestions and implementations are seen. In the report "Blockchain in Education" published by the European Commission in 2017, use case scenarios of blockchain technology in areas such as certification, lifelong learning, tuition fees, and scholarship payments to students were suggested (Camilleri, 2017).

According to an application scenario included in the report, in case of a malfunction or closure in the information system of an educational institution, it will be possible to access all certificates and student outputs produced by that institution through the blockchain system. In the report, it was also stated that thanks to smart contracts, payments such as scholarships and coupons can be made to students without the need for any intermediary, and payments for education can be received with electronic currencies.

One of the most well-known blockchain studies in the field of education is made by Turkanovic, et al. (2018). In this study, researchers developed an application called EduCTX, which allows institutions to store the credit information of higher education students in the blockchain in accordance with ECTS (European Credit Transfer and Accumulation System) (Turkanovic et al., 2018).

Thanks to this application, students can see the course credits, which they have completed in different institutions, simultaneously in their accounts on the blockchain. In addition, participating higher education institutions can perform transactions such as application and document verification via the blockchain.

In another study, Cheng et al. (2018) developed an application to keep diplomas and certificates on the blockchain instead of producing them on paper. It has been stated that thanks to the application presented, problems arising from situations such as the loss and destruction of the document printed on paper will be prevented. Thanks to the digital verification mechanism offered by the blockchain, companies or educational institutions were given the opportunity to verify the documents of the students who applied for a job.

Blockchain leads the digital transformation of these sectors by offering features and services that can overcome the problems encountered in many areas other than the areas mentioned above. As sectoral examples, the prevention of fake news in the media, production, distribution, and payment transactions in the energy field, logging in the IT field, spam prevention, data verification, and royalty management in the publishing field can be given.

Conclusion

Blockchain, which first entered our lives with digital currencies, quickly became popular and could be applied in many areas. Thanks to its distributed architecture, blockchain enables stakeholders to rely on mathematics, encryption, internet, and computing power instead of central authorities or third-party companies. Blockchain is like the technologies that have entered our lives unawareness and become inevitable, such as the internet, mobile technologies, cloud services, and the HTTPS protocol in terms of its emergence and prevalence. It is estimated that a similar digital transformation led by these technologies will be experienced thanks to the blockchain. Today, a large amount of data is generated as a result of the widespread use of IoT devices and information technologies. The information to be obtained from these data is of great importance for increasing the quality of service, advertising, and R&D activities. Therefore, in this period, which is also called Industry 4.0, issues such as data sharing, data security, transparency, and avoidance of centralized structures attract institutions and individuals. At this point, blockchain has attracted the attention of companies and researchers thanks to its features such as smart contracts, digital signature and distributed architecture, and it leads the development of solutions that make life easier in many areas. In this study, firstly, information is given about the concept of digital transformation and blockchain.

In the following sections, the definition, features, development process, types, and services of the blockchain are explained.

Finally, the contribution of blockchain to digital transformation was mentioned and information was given about theoretical and implemented blockchain-based applications in many fields such as supply chain, finance, education, and health. These applications, which are increasing in number and spreading rapidly, have brought about an evolvement and change in different sectors.

As a transformative technology, blockchain has entered our lives in many areas and is still developing and becoming widespread. In this context, individuals, institutions, and organizations need to keep up with this change and renew themselves digitally. For this, it will be an important step for countries to include blockchain technology in their education curricula at different levels. Since blockchain has the potential to be used in many areas, it is critical for future generations to use this technology effectively and correctly, especially in vocational education areas such as health, informatics, communication, agriculture, industry, and the addition of elective and applied course contents in undergraduate education.The share of the information and communication sector in the world economy is gradually increasing. Blockchain technology has also taken its place as an important employment area in this regard, and new professions such as blockchain specialist, blockchain network specialist, and smart contract developer have emerged. In Turkiye, "Blockchain Programmer National Occupational Standards" were published in the Official Gazette on Monday, May 23, 2022 (Blockchain Programmer, 2022).

Creating new employment opportunities by organizing academic and vocational training for this new profession will provide an important competitive advantage for institutions and countries. Blockchain-based digital money applications attract great attention from people around the world. People use digital currencies to generate income through money transfer, investment and trading. There are many frauds and grievances in the world for digital currencies, which have entered our lives and become widespread thanks to the convenience they provide. Due to the distributed nature of the blockchain and the use of anonymous identities, there are difficulties in dealing with the grievances experienced in this area, legally with the methods in practice. In order to eliminate this deficiency, necessary legal arrangements should be made by experts in the field of informatics and law as soon as possible. Blockchain continues to develop as new technology and attracts great attention from people.

Finally, emerging NFT (Qualified Intellectual Deed) applications have become widespread rapidly and have found use in many areas. As in digital currencies, fraud and victimization are experienced in NFT applications as a result of misunderstanding and misuse of technology by people. In order to prevent these grievances, it is important to inform society about blockchain-based crypto money NFT and future applications through public service announcements and similar ways.

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