What is blockchain technology?

— The blockchain revolution began with bitcoin, which used distributed ledger technology to foster trust in a currency and transaction mechanism not backed by any government or traditional institution... —

Now anyone can create their own online money, deal in it and record transactions in their own ledgers. Put simply, we can privately issue digital forms of value. Everybody can become their own banker, insurance agent or currency cashier. How will this affect the functioning of society? What will be the consequences for the evolution of our payment and tax systems? How will the current legislation change? All this cannot be predicted. We do not know how blockchain applications will transform our civilisation. And this transformation has already begun...

THE ORIGIN OF THE IDEA

In 1991, the 'Journal of Cryptology' published a modest article[1] in which it was proposed to time-stamp the **data**, not the **medium**. The article discussed the procedure of **time-stamping** of digital information, or, in other words, introducing cryptographically secure information on the time of its creation. It was then that the question was raised of how to ensure the veracity and confidentiality of digital documents online so that they would not be falsified. Among other things, this was achieved by introducing server-based time-stamping. Soon, several documents were collected in one data block (so-called Merkle tree, see glossary), and in 2002 the idea of a network file system with a decentralised trust was published.[2] This exact proposal is considered as a proto blockchain. As early as 1995, Nick Szabo,[3] forecasting advantages from the use of cryptographic hash chains, coined the term 'smart contracts'. Later, in 2005, he described a system similar to the modern blockchain, whose application he saw in the decentralised registry of all property titles.

SATOSHI NAKAMOTO AND HIS BITCOIN

Blockchain technology was first described and applied in the concept of a digital, cryptographic bitcoin currency, published in 2008 by an unknown creator or group of creators under the pseudonym Satoshi Nakamoto.[4–9]

Satoshi's blockchain is bitcoin's general ledger for all transactions. As a result, bitcoin became the first digital currency in which the double spending problem was solved without the need for the existence of the so-called trusted third parties, such as banks.

This was the beginning of the concept of blockchains, i.e. a series of ownership records, connected chronologically with each other and secured by

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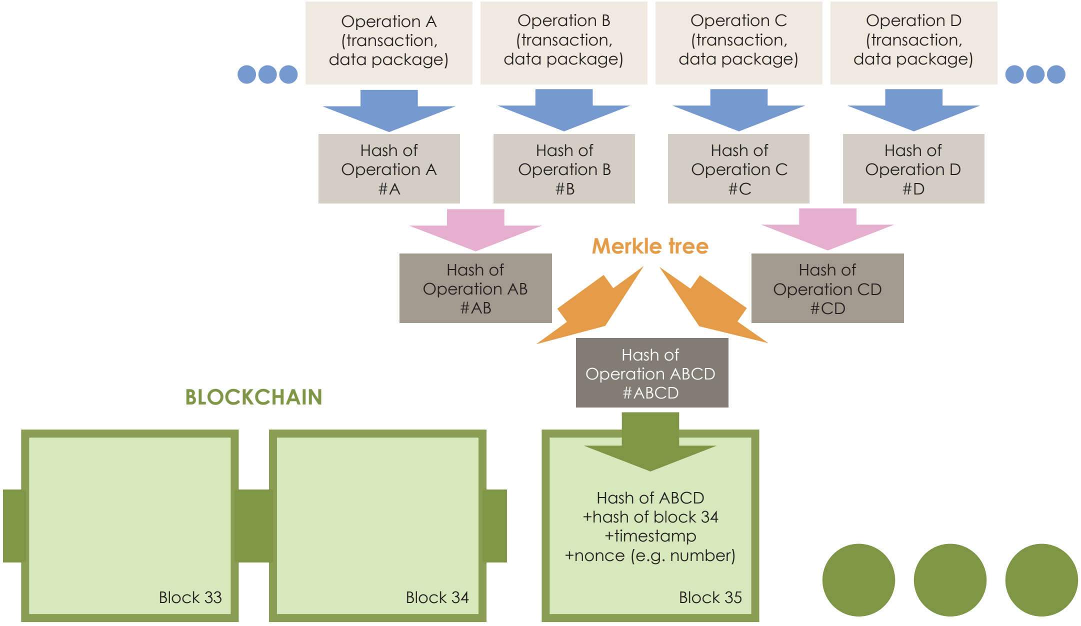

Operation A (transaction, data package)
Operation B (transaction, data package)
Operation C (transaction, data package)
Operation D (transaction, data package)
Hash of Operation A #A
Hash of Operation B #B
Hash of Operation C #C
Hash of Operation D #D
Merkle tree
Hash of Operation AB #AB
Hash of Operation CD #CD
Hash of Operation ABCD #ABCD
BLOCKCHAIN
Block 33
Block 34
Hash of ABCD +hash of block 34 +timestamp +nonce (e.g. number)
Block 35

— **Fig. 1. Blockchain design, i.e. the cryptographic ledger** —

cryptographic methods. The content of these records is usually a cryptographic hash of the previous block, a timestamp (dating), and operation data (Fig. 1). Blockchains are designed to be resistant to data modification – as it is an open, distributed but secure ledger where events between parties can be recorded in a permanent, effective and verifiable manner.

The bitcoin blockchain has already recorded 500 million transactions, and the total balance of accounts currently exceeds the equivalent of USD 70 billion. In this ledger, transactions are recorded in blocks, which are added every few minutes to form an endless record, record that has never been broken, despite many attempts by the most skilled hackers. The bitcoin ledger is resistant to manipulation and falsification.

The bitcoin blockchain is called a distributed ledger because its content is automatically and simultaneously updated on the network, and on thousands of computers, tablets and smartphones belonging to entities that do not know each other. The security of the transactions recorded in this ledger is ensured by cryptographic procedures and techniques. This reliable record of the bitcoin ledger in a public network, i.e. in an untrusted environment, is achieved by means of a very advanced procedure for checking and confirming transactions, which requires considerable computational power. This procedure allows the validation and addition of approved blocks to an existing blockchain, i.e. to record all transactions made since the blockchain was created. The validation of blocks is carried out by anonymous internet users with considerable computational power, who are waiting online to perform this procedure first. Whoever manages to validate the block first receives a financial reward in the form of a chain.

The blockchain, or distributed ledger technology, is in fact a way of endowing objects with trust in an untrusted environment, originally designed for transactions between two entities which do not know each other. Such blockchains can function as an unquestionable register of important data and events other than money transactions, such as records of property (mortgages that are immediately available worldwide), digital rights, deposits or debts, intellectual property or health records. Blockchains can be used to record the results of university exams and diplomas, or keep records of the diamonds mined, with information on the cut of each stone, its colour and weight.

Analysts see enormous potential in distributed ledger technology. The forecasted variety of applications for this technology is truly astonishing. It should be remembered, however, that these are for the most part futurological considerations, or at best only initial attempts and untested solutions, which should not be used without caution.

BITCOIN IS ONE, BUT THERE MAY BE MANY BLOCKCHAINS

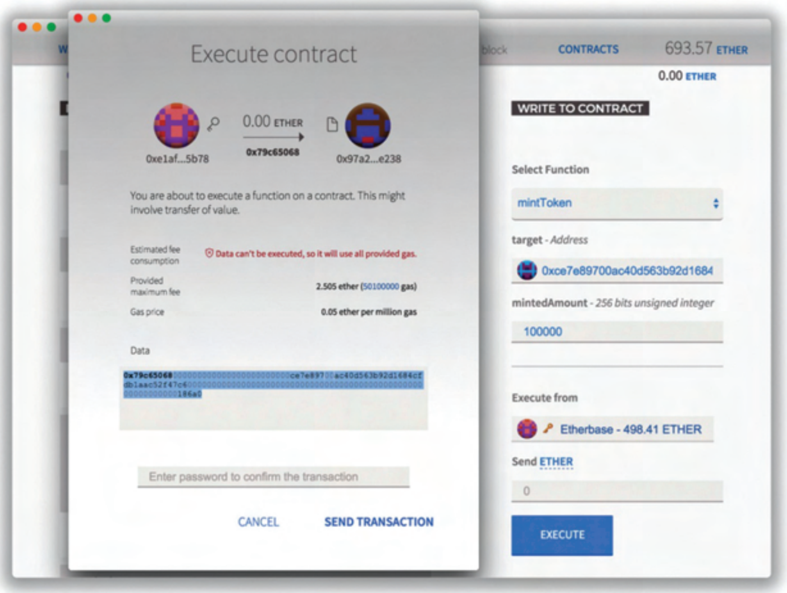
Contracts, transactions and their entries define our economic, legal and political systems. They govern the relations between nations, organisations, communities and individuals. However, the tools developed to manage these relationships are unable to keep pace with the digital transformation. We are already experiencing cases of information congestion, which resemble traffic jams in rush hour.

Moreover, in the past, governments were the only currency issuers. The governments could devalue or revalue the currency, and they could simply exchange money to gain from it. The subjects or citizens were only passive spectators of such operations.

Now, everyone can create their own representation of values and exchange its values using the distributed ledger technology. To put it simply, we can privately issue digital forms of value. Everybody can become their own banker, insurance agent or currency cashier. How will this affect the functioning of society? What will be the consequences for governance, the evolution of our tax system and changes in legislation? Unfortunately, it is still impossible to say whether and how blockchain applications will change our civilisation.

To date, blockchains have been the dominant functioning and validated tool, both in the bitcoin system and in a number of slightly improved and expanded follow-up systems, such as the Ethereum[10] created by Vitalik Buterin, which defines, among others, the ether currency.

In Ethereum, it is possible to set up private blockchains, as discussed in[11]. This requires the necessary software to be downloaded from the Ethereum repository. Firstly, Core Geth is required, which allows the sending, receiving and creating contracts on the Ethereum platform. It is also necessary to download the Mist browser, which enables convenient creation of accounts and the making of transactions.



Execute contract

0xe1af...5b78 — 0.00 ETHER → 0x79c65068 — 0x97a2...e238

You are about to execute a function on a contract. This might involve transfer of value.

Estimated fee consumption: Data can't be executed, so it will use all provided gas.

Provided maximum fee: 2.505 ether (50100000 gas)

Gas price: 0.05 ether per million gas

Data

```
0x79c65068000000000000000000000000ce7e89700ac40d563b92d1684cf
db1aac52f47c6000000000000000000000000000000000000000000000000
00000000000186a0
```

Enter password to confirm the transaction

CANCEL SEND TRANSACTION

block CONTRACTS 693.57 ETHER

0.00 ETHER

WRITE TO CONTRACT

Select Function: mintToken

target - *Address*: 0xce7e89700ac40d563b92d1684

mintedAmount - *256 bits unsigned integer*: 100000

Execute from: Etherbase - 498.41 ETHER

Send ETHER: 0

EXECUTE

— **Fig. 2. Ethereum application screenshot** —

Ethereum allows you to create blockchains with multiple functions, for example, those allowing the storage of accumulated ethers (ETHs). This is the unit of account of that currency. There are many available units, starting with wei at 10^{-18}, all the way to tether at 10^{12}. The hash function used in Ethereum is Keccak–256 (SHA–3), which has a higher capacity than SHA–2, implemented in bitcoin. To initiate a new blockchain, it is necessary to create the first block, i.e. the genesis block. Presented below is a principal configuration file for the Ethereum genesis block, which is recorded in the genesis.json file. The options provided in the block define: the calculation difficulty relating to a task performed while validating the block (the given sample value allows the validation of a block within a dozen or so seconds using even limited computational resources), the limit of calculations performed for transactions, i.e. the maximum cost of transaction conversion, the network identifier (100), the version of the used structure of the blocks and the initial funds for selected accounts (in this case none).

```
{  "difficulty":  "0x400000",  "gasLimit":  "0x8000000",
"config": { "chainId": 100, "homesteadBlock": 0, "eip-
155Block": 0, "eip158Block": 0 }, "alloc": { } }
```

The following command `geth --datadir ./eth init genesis.json` will generate our private blockchain based on the genesis block. It will consist of only one block. The next step is to activate a local node. The following command `geth --datadir ./eth --networkid 100` should be used. After the node is activated, a remote procedure call (RPC) can be used for communication. We can then see the current state of the blockchain, view the data contained in it and order new transactions.

HOW USEFUL CAN BLOCKCHAINS BE IN BUSINESS?

The recording of all current data, both internal and transaction data, is the basis of every company's activity. These records include previous actions, results and elements of planning. All entities, not only economic entities, store their data. Many of them do not have a general ledger for all its activities. Instead, it has records transmitted between internal units. The reconciliation of transactions in individual led-gers usually takes a long time and is susceptible to errors.

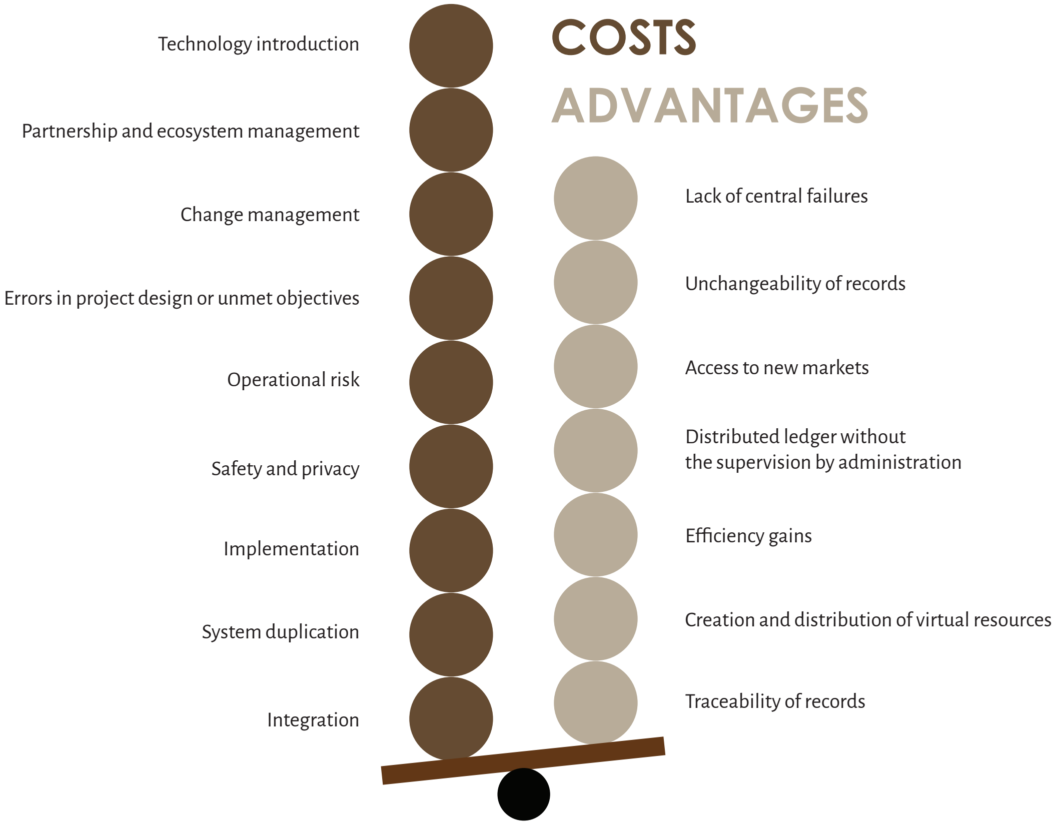
For example, a typical exchange transaction can be executed within several microseconds, often without human intervention. However, the transfer of ownership can take up to a week as the parties often do not have access to their ledgers and cannot check the ownership and transferability online. Therefore, there must exist a whole range of intermediaries, such as asset guarantors or banks.

In blockchain technology, a ledger is replicated in the form of a large number of identical databases, and each of these databases can be managed by an interested party. When changes are made to one copy, all other copies are updated automatically and simultaneously. The entries of values and assets are simultaneous in all ledgers. External intermediaries do not need to verify anything or transfer ownership rights. For example, if an exchange transaction is carried out in a blockchain system, the exchange will be posted within a few seconds in a safe and verifiable manner. To date, all successful hacking attacks on bitcoins have exploited only the gaps in user computer systems, and not in the source software.

It may still be necessary to wait a little longer for the blockchain technology to reach its full potential. However, the emergence of new applications that will transform economic, social and political systems are already forecasted. The forecasted activities include, for example, the coordination of the activities of numerous entities and the reaching of an agreement on standards and processes.

Currently, the most interesting applications are the already functioning smart contracts described below. They enable making an automatic payment to a supplier immediately after the delivery of a shipment. A company may indicate through blockchain that the goods have been received. The product could also be located via GPS.

At the end of 2016, the value of bitcoin transactions was estimated at USD 92 billion. This still is a rounding error against USD 411 billion in global payments. However, bitcoin is growing rapidly and assuming an increasingly important role in immediate payments,



— **Fig. 3. Current costs and advantages of implementing blockchain technology** —

foreign exchange turnover and asset trading, which are restricted in the existing financial systems.

There are also difficulties, however. If contracts become automated, what will happen to traditional corporate structures, such as legal and accounting departments? And what about managers? Their roles will change drastically. It is expected that a number of years will have to pass before this happens. Also, the expected technological difficulties, especially with regard to security, are unfortunately discouraging.

These predictions must also not forget about the most important element – society's civilisational resistance. An interesting experiment conducted in 2014 at MIT illustrated the challenges faced by digital currency systems based on blockchains. MIT Bitcoin Club offered USD 100 in bitcoins to each of over four thousand students. As much as 30% of students did not collect the resources on offer, while 20% of students only collected them a few weeks later. It turned out that even technically educated and intelligent people had difficulties with understanding why, where, and how they could use this cryptocurrency.

SMART CONTRACTS

In fact, the most important feature of blockchain technology, although rarely discussed and even omitted in an embarrassed manner from descriptions, is that it is free of charge. In the world of finance, things that cost are considered of value, and it is not fitting to praise anything which is free to have. However, blockchain technology is an extremely valuable, decentralised cryptographic system, and one that does not cost anything. One does not need to pay any intermediaries; the system saves time and reduces the risk of conflicts. The technology has its problems, but it certainly allows for faster, cheaper and more secure value transfers than traditional systems. That is why governments, banks and companies are turning to it.

As previously mentioned, in 1994, Nick Szabo, a legal scholar and cryptologist, realised that the decentralised ledger could be used for the so-called smart contracts, otherwise known as self-executing, blockchain or digital contracts. Such contracts help you exchange money, purchase property and shares, or anything of value.

Smart contracts are already being used to carry out a wide range of operations – financial derivatives, insurance premiums, infringement agreements, agreements on rights in property, financial services, loan enforcement and even social financing agreements. Moreover, similarly to conventional contracts, smart contracts not only define the rules and penalties, but also automatically enforce those obligations.

For the sake of clarity, let us compare a traditional transaction with an automated one. In the case of a conventional transaction, it is necessary to make a visit to a lawyer or a notary who checks our identity, agrees on the text of the document and collects the fee, and only then issues a signed document. In the case of an automated transaction, the amount is simply transferred and the confirmation document is sent to our smartphone or is archived in an appropriate file accessible by us online.

In this way we can rent a flat, for example: we create a smart rental contract using a blockchain and pay with cryptocurrency (currently most often by means of the Ethereum software, as it has the most extensive capacities). Once the payment is made, we receive a receipt resulting from the contract made. At an agreed deadline we receive a digital access key. If the key is not delivered on time, blockchain will refund the payment made. If this key is sent before the rental date, the transaction will be halted until the specified date of rental. The system works on an if-then basis. This means that a fair deal can be expected: if I give you the key, I will get the payment: if you make the payment, you will get the key.

Here is a sample fragment of a smart contract code contained in the Ethereum blockchain (Fig. 4). This contract could also be included in the blockchain of any application.

The technology of smart contracts currently takes advantage of new forms of fund acquisition and the decentralised contract organisation, the so-called Initial Coin Offering (ICO), which is under criticism from the Polish Financial Supervision Authority (KNF). The Decentralised Autonomous Organisation (DAO) is also a novelty (see: glossary).

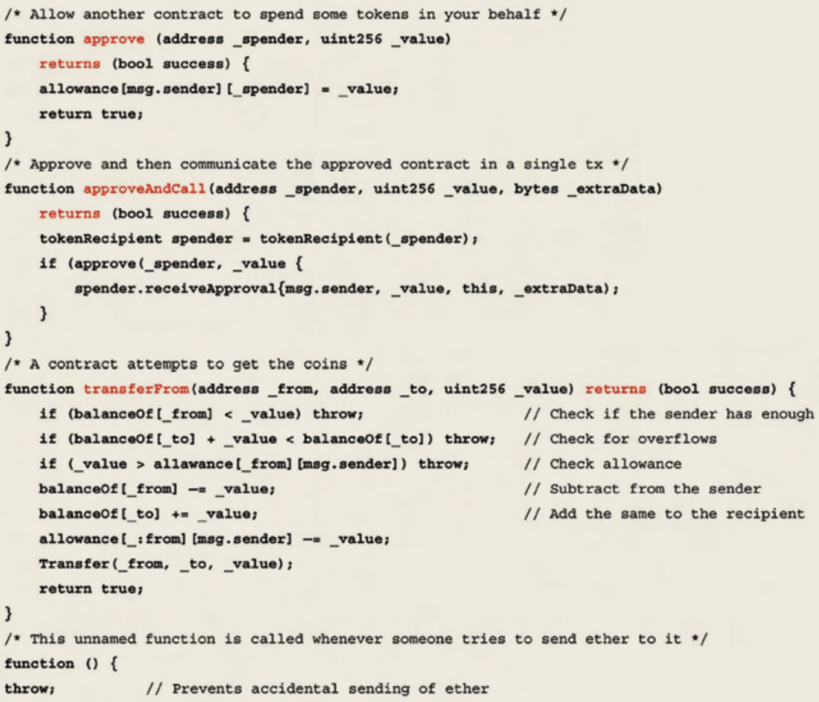
A LITTLE CAUTION

Although many blockchain solutions can be perfectly implemented using existing and reliable tools, such as relational databases in the cloud, it is already widely believed that blockchain technology will transform the society we live in. Not tomorrow, but maybe the day after tomorrow. Some forecasts say that by 2022 the portfolio value of innovative companies using blockchain technology implementations will exceed USD 10 billion.

The use of cryptographic technologies carries a risk. The definition of a blockchain is not precise and its potential applications are only forecasted. Implementations vary in the degree of their functionality. Many of the proposed solutions have not yet gone beyond the concept phase. Recently, there has been an increase in the number of attacks on smart contracts in particular. It would be challenging, however, to create a more accurate risk model on the basis of which a risk assessment could be carried out. A blockchain is a complex IT system and it lacks the transparency offered by more traditional solutions.

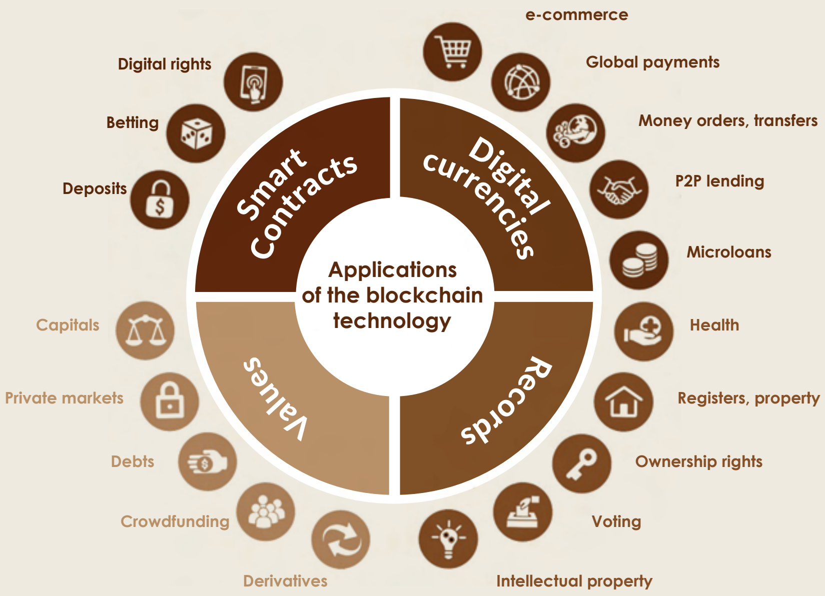
Generally speaking, blockchain technology is new and people do not understand it yet. There are still no standards, normative regulations or provisions concerning it. Some opinions say that the praise for the future of blockchain technology is pure ‘evangelist marketing’, which diverts attention from its ordinary and effective applications.

Most specialists believe that blockchains will revolutionise the world of business and redefine companies or even entire economies. However, our experience in the area of innovative technologies teaches us that in order to make progress, many barriers need to be overcome: of technological, organisational and even social character. The real transformation of the business and administration world must certainly take some time. Blockchain technology is also unlikely to undermine traditional business models by means of cheaper solutions to replace ‘outmoded’ institu-



```
/* Allow another contract to spend some tokens in your behalf */
function approve (address _spender, uint256 _value)
    returns (bool success) {
    allowance[msg.sender][_spender] = _value;
    return true;
}
/* Approve and then communicate the approved contract in a single tx */
function approveAndCall(address _spender, uint256 _value, bytes _extraData)
    returns (bool success) {
    tokenRecipient spender = tokenRecipient(_spender);
    if (approve(_spender, _value {
        spender.receiveApproval{msg.sender, _value, this, _extraData);
    }
}
/* A contract attempts to get the coins */
function transferFrom(address _from, address _to, uint256 _value) returns (bool success) {
    if (balanceOf[_from] < _value) throw;                // Check if the sender has enough
    if (balanceOf[_to] + _value < balanceOf[_to]) throw;  // Check for overflows
    if (_value > allawance[_from][msg.sender]) throw;     // Check allowance
    balanceOf[_from] -= _value;                           // Subtract from the sender
    balanceOf[_to] += _value;                             // Add the same to the recipient
    allowance[_:from][msg.sender] -= _value;
    Transfer(_from, _to, _value);
    return true;
}
/* This unnamed function is called whenever someone tries to send ether to it */
function () {
throw;          // Prevents accidental sending of ether
```

— Fig. 4. Fragment of a sample smart contract procedure —



— Fig. 5. Forecasted applications of the blockchain technology —

tions. It is a fundamental technology. It has the potential to create new foundations for our economic and social systems. But the acceptance process must be gradual and permanent, while the wave of technological and institutional changes must first gain momentum.

Blockchain technology is already attracting a lot of attention from various industries and continues to be one of the most popular topics in online searches. What is more, the information noise around this technology makes people perceive digital currencies as an opportunity to be explored. Those responsible for the condition, development and implementation of information technology in enterprises encounter numerous problems when implementing these new complex cryptographic technologies. Although they are open to the advantages provided by blockchains, they are also apprehensive about multiple potential hazards. In the short term, this caution will mean that most entities, apart from the most pioneering companies, will be left behind in the implementation of blockchain technology.

At present, analysts believe that the majority of projects in preparation will be implemented without the use of blockchain technology. This is because there are still many unresolved problems, including legal and regulatory issues, as well as serious reservations regarding the actual functioning of society in distributed autonomous P2P networks (peer-to-peer networks).

The approach of the business world to cryptographic blockchain technology is cautious. One SWOT analysis (see box) calls for vigilance. However, there are also some promising attempts.

HOW CAN BLOCKCHAIN TECHNOLOGY TRANSFORM OUR REALITY?

Many of the forecasted applications for blockchain technology have already been discussed above. However, apart from smart contracts, this is only the beginning. The key prerequisite for the development of open cryptographic web applications is reaching managers with suitable knowledge on the strengths, weaknesses, opportunities and threats of new technologies. Business leaders must first acquire the knowledge on which of the key problems can be solved, at least partially, with the use of blockchain technology. First of all, they should be aware that, so far, none of the hundreds of blockchain applications are widely used, even in the financial services industry.

At the end of 2016, a global consulting firm conducted a fascinating study on a large number of leading companies specialising in payments, including central banks. The respondents were asked how many entities out of 32 entities participating in the analysis of the usefulness of blockchains (Proof of concept, PoC) implemented blockchain technology within the last two years. All the answers given were positive. There were only four positive answers to the second question, which asked how many of them continued to use cryptocurrencies. What is more, only one of the participating representatives worked in bitcoin online software, but it was only its testing environment.

It turned out that none of the represented entities were ready for this technology. Not only in terms of insufficient knowledge, but also, as mentioned previously, in terms of the lack of legal frameworks, risk, accounting, culture and business strategy. The problem, therefore, is not in the details or applications.

The use of cryptographic technologies in the open onternet, and especially applications based on blockchains, in a strategic dimension can change our entire reality in which we exist. As was the case with the internet once, blockchain technology is able to transform the dynamics of entire industries and alter the market role of the main actors in our reality, such as banks, government agencies and law firms. Neither state economies nor administrative bodies will be immune to these changes. •

—

Blockchain technology is the most significant IT innovation of the last decade. The security of this technology, which is based on cryptographic distributed databases, results from mass use, instead of secret operations of powerful data handling institutions...

—

Glossary

Merkle tree, hash tree – a type of data structure which contains a tree of summary information about a larger piece of data. Hash trees are a generalisation of hash lists and hash chains, which in turn are an extension of hashing. Hash trees were invented in 1979 by Ralph Merkle.

Blockchain – a cryptographic structure of events recorded in the open Internet, cryptographically secured and protected against tampering.

Hash function – this function maps data of arbitrary size to a hash of a fixed size, and is a function which is infeas-ible to invert. In IT, hash functions allow for the creation of signatures which are short and easy to verify.

Nonce (number used once) – a unique value which is used only once with a given key, for instance, a block number.

Smart contracts – digital contracts with programmable and pre-defined conditions. Smart contracts are one of the applications of blockchain technology. The concept for this solution was created in 1996, more than 20 years ago, but it is only now that the appropriate software has been developed (the Ethereum system, which constitutes an evolution of the bitcoin software). The execution of smart contracts is based on sequencing, i.e. enforcing individual lines of code. To put it simply, if event A has occurred, then event B will occur. It is a process that can 'happen' simultaneously in thousands of blockchains. The central idea of smart contracts is to use the blockchain technology not only to carry out specific types of action, but also to enable their automated verification. After positive verification, the system automatically begins to perform the transaction. Smart contracts currently possess enormous computational power and provide new and extensive opportunities for all sectors of the economy.

ICO (Initial Coin Offering) – a 'call for funds-type' initiative, announced by, among others, start-up companies on Internet forums (most frequently in Bitcointalk) to raise capital from those who made a decision to support a particular project. The ICO is always announced before the project is completed. The ICO is an advantageous method of financing projects because the supporters, who believe in its success themselves, tend to tell others about the new project, which increases the success of the call for funds. Unfortunately, this method of fundraising is sometimes used by fraudsters or hackers spreading viruses and trojans.

DAO (Decentralised Autonomous Organisation) – a particular form of a smart contract with a completely autonomous entity which exists only in cyberspace. The first DEO funding action was carried out in 2016, and the money raised was actually transferred to a completely independent, decentralised and autonomous organisation that only existed online. This action failed; however, as some of the funds raised by the ICO were taken over by a hacker. The internet reacted to this situation in a surprising manner: the interest shown in DAO increased and the amazing potential of this form of funding was recognised.

What is a blockchain?

A blockchain is a cryptographic mechanism for recording transactions, which is attractive especially to innovative companies, both start-ups and those well-established in the market.

Blockchain technology introduces a trust architecture that enables both people and machines to perform commercial transactions and to record events, e.g. acts of law.

The system contains numerous undeveloped and untested concepts, especially when used in critical, scalable business processes.

The blockchain technology operates outside the traditional legal, accounting and institutional frameworks and goes beyond conventional procedures which have passed the test of time.

It is an alternative computer model that uses distributed and decentralised computer networks to provide a higher level of security and lower costs than traditional methods.

It introduces a new way of managing trust between the untrusted parties by offering transaction records which are impossible to forge.

The technology continues to feature many uncertain and undeveloped procedures. It is therefore considered that its users should remain aware of the increased operational risks in the coming years.

SWOT analysis

Blockchain technology has been and continues to be subject to various analyses to investigate possible difficulties and hazards in advance. Here is the result of a SWOT analysis – Strengths, Weaknesses, Opportunities (potential or existing opportunities), and Threats (probable or existing threats) – a key tool for creating marketing strategies and business plans, conducted by Gartner Inc., a global consulting company.

Companies no longer need to sign multimillion contracts to explore the potential of blockchain technology. Instead, one should assess the potential of this technology and the purposefulness of its implementation in one's own business model, existing technologies and processes, as well as in risk management.

S

- distributed resilience and control
- decentralised network
- open source
- cryptographic security
- asset provenance
- native asset creation
- fluid value exchange

W

- lack of ledger interoperability
- customer unfamiliarity
- lack of tested/hardened technology
- limitation of smart contract code programming model
- programmer inexperience
- immature scalability
- lack of trust in new technology suppliers

O

- reduced transaction costs
- efficiency increase
- reduced fraud
- reduced systemic risk
- monetary democratisation
- new business-model enablement
- application rationalisation and redundancy

T

- legal barriers
- hostile nation-state actors
- technology failures
- institutional adoption barriers
- divergent blockchains
- ledger conflicts
- poor governance

Method of accounting VAT transactions without a blockchain system.

The company issues a VAT invoice.

The client pays the gross invoice, including the VAT amount.

The company posts the payment.

The company pays the supplier's bill with a bank transfer.

The company calculates the VAT due to the tax authorities and completes the tax return (monthly, quarterly, annualy).

Method of accounting VAT transactions with a blockchain system.

The client pays, the smart contract calculates and pays the VAT due, and transfers the remainder into the appropriate bank account.

The company pays the supplier's invoice using a smart contract: it transfers the liability to the supplier and pays the VAT amount due to the tax office using a smart contract.

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