Blockchain Meets Democracy 2.0

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Abstract. In the political system of democracy, power and government come from the people. The principle has existed for over 26 centuries. During this period, the system has undergone constant development and has always adapted to changing demands. This traditional form of democracy can no longer meet the requirements of the majority of today's society. It faces growing political discontent. Democracy 2.0 is a way of increasing public political participation through direct interaction. Electronic voting systems, or e-voting, can operationalize this type of direct co-determination but must meet the high requirements of the democratic electoral system of Democracy 2.0 at the time of introduction. Blockchain technology provides the technological basis that could make e-voting possible right from the start. The present paper therefore aims to examine the blockchain technology's suitability for e-voting as a pioneer of Democracy 2.0. Case studies from several countries will be considered, and, based on them, recommendations for a software service company as a potential developer of such a solution will be derived. Moreover, a business model will be developed that includes the findings from the case studies and applies them to the software service company. The generated findings prove that the technology is able to combine security, privacy, and transparency with the need for more flexibility when voting. In addition, efficiency and cost savings can be realized through the electronic version.

Keywords. blockchain · Democracy 2.0 · e-voting

1. Introduction

Today, more than ever, Western democracies are facing major challenges. Due to the growing distrust of politics, representative democracy has come under heavy criticism. This mistrust is reinforced by a feeling of non-representation by parties and parliaments and an increased polarization in society. This had led to the growing popularity of populist parties.

An increase in citizen participation offers a solution to this problem (Bohne & Bukow, 2018). This idea is also behind the relatively new concept of Democracy 2.0, which, despite the lack of a uniform definition, can be understood as a renewal of existing democracy by incorporating more direct democratic elements (Azuma, Person & Matsuyama, 2014). This is made possible in particular through the use of digital technologies.

Digitization is changing every area of life; it transfers people and their working and living environments to a digital level (Hamidian & Kraijo, 2013). According to the study by Initiative D21 (2018), 81% of Germans were regularly online in 2017, including 64% on a mobile device. Both figures have risen significantly compared to the previous year, which indicates a progressive spread of digital technologies in society. A Forsa survey from 2013 showed that 51% of voters would use online voting in the 2013 federal election. In addition, almost two-thirds of all Germans are interested in online participation in political discussions and votes (Pommer, 2013). According to a Kaspersky study, the proportion of potential online voters has risen to around 56% in the 2017 federal election. The majority of respondents also see an e-voting solution as a way to achieve more direct democracy and higher voter participation (Roesner, 2017).

Despite the positive attitude of German citizens towards e-voting and the relatively high degree of digitization in society, such solutions have not yet been implemented. In 2009, the Federal Constitutional Court (BVerfG) ruled that the use of voting computers was unconstitutional. This was justified by the fact that citizens cannot be protected against possible manipulation and that the digital input of the vote cannot be validated by the citizen (BVerfG, 2009). A solution to the problem is offered by blockchain technology, a decentralized, cryptographically secured, verifiable, and unalterable data structure (Lacity, 2018; Puthal, Malik, Mohanty, Kougianos & Yang, 2018). This enables a tamper-proof and at the same time cost-effective election process (Hjálmarsson, Hreiðarsson, Hamdaqa & Hjálmtýsson, 2018). In addition, a blockchain-based e-voting solution can be tailored to the application due to its open character. Thus, elections can be implemented both within companies as well as locally, nationally, and internationally (Kshetri & Voas, 2018). Due to these characteristics, blockchain has the potential to revolutionize democratic voting systems and pave the way toward Democracy 2.0 (Müller, 2017).

The present study primarily deals with the question as to the extent to which blockchain can be used as a pathfinder for Democracy 2.0. In Germany, there is a lack of approaches or business models for conducting elections using blockchain technology, which is why the question of how a company can benefit from it is posed.

Within the framework of the elaboration on this topic, an application scenario involving the use of blockchain technology with regard to Democracy 2.0 for an example software service company will also be examined, including how this application can be designed in concrete terms.

2. Democracy and Democracy 2.0

Since the 5th century B.C., democracy has undergone many developments and has always adapted to changing requirements. In ancient Athens, the citizens decided in ostracism who should be banished from the community. Over the last 26 centuries, democracy has developed from this basic form of popular rule into a multitude of constitutionally formalized states (Frevel & Voelzke, 2017).

2.1. Historical development

The term democracy is derived from the ancient Greek words *demos,* for people, and *kratein,* for to rule. Like the term, the idea for this form of rule comes from pre-Christian Greece (Frevel & Voelzke, 2017).

Since the time of the ancient Greeks, many political theorists have expanded upon and supplemented the concept of democracy. In the following, we will briefly discuss those contributions that essentially influenced the free democratic basic order of the Federal Republic of Germany (FRG)—respect for human rights, popular sovereignty, separation of powers, and the legality of administration (Lautner, 1978).

2.1.1. *Constitutional state*

In his work *Leviathan*, published in 1651, Thomas Hobbes, influenced by the confessional civil wars of the time, postulated the protection of life as the highest goal of a legitimate state. Influenced by a very pessimistic view of humanity, his highest goal was to solve struggles among citizens. This was to be achieved by means of a social contract in which a separate state authority was determined by the people. The highest goal of the state authority should be to guarantee the peace and security of the citizens. In his work, Hobbes does not bind the ruler thus elected to any further obligation, making his idea more akin to a totalitarian or autocratic system. Hobbes's treatise is the first forerunner of a modern constitutional state whose aim is to guarantee legal certainty. In the following centuries, this concept was expanded to the modern understanding of the German constitution (Hobbes, 2008).

2.1.2. *Human rights and representation*

John Locke wrote his work *Two Treatises of Government* in 1689. In it, the outlined social contract goes further than that in Thomas Hobbes’s work. The legitimation of the sovereign also comes from the consent of all. His powers, however, only extend to the inalienable natural rights that every human being holds. Here lies the foundation for the modern concept of human rights. In addition, Locke established another principle of modern democracies: By transferring the individual rights of citizens to the ruler and the resulting legitimation, a mandate relationship emerges that is considered the precursor of the principle of political representation (Locke & Laslett, 1960).

2.1.3. *Separation of powers*

Disappointed by the injustice of absolute rule under the French King Louis XIV, Charles de Montesquieu wrote his major political work *The Spirit of Laws*. In addition to a categorization of different forms of government, Montesquieu elaborated his idea of the division of power into three powers, the legislative, the executive, and the judicial. The division of these three powers into different bodies that control and monitor each other was intended to make it more difficult for the rulers to abuse their power (Montesquieu, Cohler, Miller & Stone, 1989).

2.1.4. *Popular sovereignty*

Jean-Jacques Rousseau contradicts the model of the separation of powers. For him, in a free state, power can only be exercised directly by the people, who, as the supreme authority, may neither transfer nor divide their own powers. This basic idea of radical sovereignty of the people was further elaborated in 1762 in his work *The Social Contract or the Foundations of Constitutional Law*. The obvious conflict between the individual interests of citizens in direct discourse with one another is resolved here by the people understanding themselves as a unit and combining their individual wills into a reasonable overall will (Rousseau & Gourevitch, 2018).

2.2. Forms of democratic participation

There were two ideas over time about how citizens should participate in the democratic process. On one hand there is the direct democracy demanded by Rousseau, and on the other there is the representation favored by John Locke.

2.2.1. *Direct democracy*

The historical archetype of democracy, as it was practiced in Greece in 500 B.C., is in broad terms a direct democracy. The assembly of all citizens collectively deliberated on political decisions, made them, appointed officials, and monitored their work. One reason for this was the small geographical extent of the city-states at that time. Moreover, the total number of citizens was very small at less than 200,000. At that time, neither women nor slaves nor immigrants was entitled to vote. As a result, the size of the assembly rarely exceeded 20,000 citizens (Meyer, 2009).

Switzerland is an example of a modern state with a high proportion of direct democratic participation by the population. Here, theoretically, all bills can be subjected to a referendum or plebiscite. For some far-reaching political decisions, the consent of the population is mandatory (Frevel & Voelzke, 2017).

2.2.2. *Representative democracy*

With the emergence of the territorial states in the 19th century, the limit of direct democracy was reached from an organizational point of view. In the small city-states of ancient Greece, it was still possible to reach decisions directly in assemblies of citizens, but in the recent past, spatial expansion and population figures no longer allowed for this. To solve this problem, the principle of representation already having been introduced by John Locke was taken up. This reduced the organizational effort and yet still included the democratic principle of the participation of all citizens (Meyer, 2009).

The principle of representation is particularly pronounced at the national level in the FRG. At the federal level, the people elect their representatives to the Bundestag, who have extensive powers in regard to the election of the Federal Chancellor, government control, and the right of legislative initiative (Frevel & Voelzke, 2017).

Practice shows that the theoretical manifestations of direct and representative democracy in its pure form are very rare. In modern democracies, there are different views on the weighting of direct and plebiscitary elements, but elements of both approaches are often represented. In the FRG, for example, the mayor is directly elected at the municipal level, and there are referendums at the state level (Frevel & Voelzke, 2017; Meyer, 2009).

2.3. *Democracy 2.0*

Classical democracy, as described in the previous sections, faces the challenge of increasing political dissatisfaction among the population.

Examples of this are the trends toward nationalism and populism as well as distrust of supranational alliances, such as the EU (Gehring et al., 2017). However, the reason for this growing disenchantment with politics is not so much the democracy itself but rather the political establishment of representative democracies (Fisher, 2017). Democracy 2.0 offers a starting point for remedying this lack of popular trust in specially elected representatives (Leggewie & Bieber, 2010).

2.3.1. *Term*

The concept of Democracy 2.0 and its elements are still not clearly defined in science. In Hollander and Longo (2008), the concept of Democracy 2.0 is to be understood as a combination of democracy and new social media that can motivate young citizens in particular to participate more intensively. A similar definition is found in Macnamara (2012), who sees Democracy 2.0 as an opportunity for digital media to motivate the younger population to participate in the democratic process. In Sell and Stratmann (2011), the term Democracy 2.0 refers to economic theory to explain the competition between political parties according to Anthony Downs.

Despite the different views on the term, at the core of each approach is the goal of increasing the political participation of citizens through direct interaction, which is relevant in the further course of the paper.

Therefore, the greatest substantive coverage is provided by the definition of Azuma et al. (2014). According to these authors, Democracy 2.0 is not a pure combination of democracy and new media but rather a higher-level democracy that is renewed by more direct democratic elements.

This renewal requires a more intensive involvement of citizens in decision-making processes through voting and plebiscites. This creates additional effort for the implementation of voting and the evaluation of results. Electronic voting procedures offer a starting point for reducing this effort.

2.3.2. *Electronic voting procedures*

The debate on electronic voting procedures is marked by reports about the susceptibility of existing systems to manipulation due to technical restrictions.

One example of this is the 2005 German parliamentary elections, in which voting computers were used. The Federal Constitutional Court has ruled on the basis of election review complaints that the use of these devices does not conform to the constitution. The main reason given for this is the violation of the principle of the public nature of the election. Every citizen must be able to check without any great expertise whether his or her own vote has been received. There may be exceptions in favor of other constitutional concerns. Due to the lack of security of the voting machines against manipulation, however, no exception was permitted (BVerfG, 2009).

A successful solution for conducting electronic elections must be characterized by its security against manipulation. The suitability of blockchain as a basis for such a system is examined below on the basis of use cases.

3. Blockchain

The concept of the blockchain is based on the Bitcoin white paper published by Satoshi Nakamoto in 2008. At that time, the developer needed a decentralized, public, and non-manipulable data structure for his crypto currency that allowed for the storing and public viewing of individual transactions. Because this could not be achieved with conventional databases, he took up the theory of cryptographically secured concatenations from the 1990s and developed it further into today's blockchain (Palkovits, Pohlmann & Schwedt, 2017). Since then, the public has been intensively engaged with the technology. This has led to the development of new applications (e.g., Smart Contracts), even beyond crypto currencies, which have the potential to usher in a new generation of the Internet of Values (Prinz, Rose, Osterland & Putschli, 2018).

3.1. Structure and functioning of blockchain

Blockchain is a simple data structure consisting of a series of interlinked blocks. Each of these blocks has a so-called block header and a block body (Palkovits et al., 2017; Zheng, Xie, Dai, Chen & Wang, 2017).

The block header contains information about the version of the block (Block Version), the hash value of all the transactions in the block (Merkle Tree Root Hash), and the current time in seconds since January 1, 1970 (timestamp). In addition, the threshold value of a correct block checksum (nBits), a random number that increases with each hash calculation (nonce), and the hash value of the previous block (parent block hash) are stored in the block header. The block body consists of the transaction counter and the transactions. The maximum number of transactions that can be stored within a block depends on the block size (Zheng et al., 2017).

The presented characteristics of a block, especially the coding of transactions by hashing, ensure a high level of security of the blockchain. The modification of a transaction causes the generation of a new hash value. As a result, the hash tree would no longer be consistent, and the manipulation would be discovered at the latest during validation (Schütte et al., 2017). To prevent an incorrect block from being added to the blockchain, the transactions are also checked for validity by the nodes of the network. The selection of the node that appends the new block to the chain is done by consensus (Palkovits et al., 2017).

The most widely used consensus method is proof of work, which is mainly used for the two largest crypto currencies, Bitcoin and Ethereum. The nodes (miners) compete with each other by solving a mathematical problem. The task is to find a number (nonce) that, combined with the new block, results in a certain hash value (e.g., with five leading zeros). This can only be achieved by multiple rounds of trial and error. The node that has solved the task the fastest can insert the block into the blockchain. The miner is then rewarded accordingly. However, this procedure requires a great deal of computing power and is therefore strongly criticized because of its high energy consumption (Prinz et al., 2018).

An alternative to proof of work is proof of stake, which is used especially for private blockchains. With proof of work, the selection of a node is based on its share of blocks added to a blockchain. The probability of being selected is therefore higher for miners who own several shares (coins). In addition to the great time and energy savings, there is another important advantage of the proof of stake method over proof of work in that the proof of stake process is much safer in comparison. For example, the blockchain can no longer be manipulated by pseudo miners who validate blocks incorrectly (Morabito, 2017; Palkovits et al., 2017). In addition to the two basic protocols presented, there are other consensus-finding procedures (e.g., delegated proof of stake), which will not be discussed in this paper. However, these are described in detail in the work of Zheng et al. (2017).

After a block has been successfully validated, it is inseparably linked to the already existing blocks. Those blocks for which a consensus has not yet been reached are placed on a list of substitutes. This ensures the transparency of the blockchain. The chain thus created is then distributed to the remaining nodes for persistence assurance so that every node in the network has a copy of the entire blockchain. However, this practice also attracts criticism since keeping the same data multiple times requires a large amount of storage space (Frøystad & Holm, 2015; Schütte et al., 2017).

A blockchain is also characterized by its independence from third parties (e.g., a bank for money transfers or a polling station for e-voting). This minimizes the risk of manipulation or censorship and eliminates a central source of error (Puthal et al., 2018; Voshmgir, 2016).

3.2. Security aspects

An important security aspect of the blockchain technology is the possibility to design the access and validation authorizations according to the use case. There are basically four types of blockchain: public permissionless, private permissionless, private permissioned, and public permissioned (Palkovits et al., 2017). These differ in terms of access and validation permissions (see Figure 1).

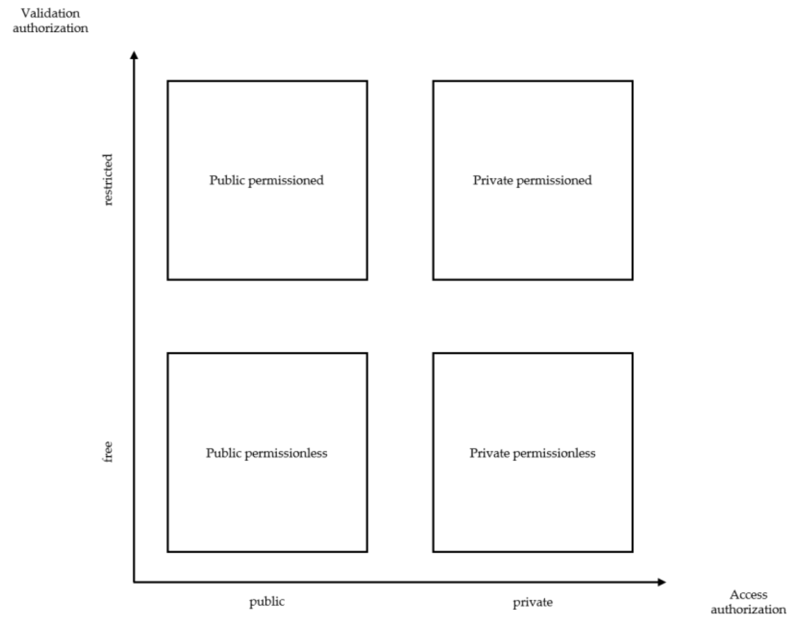

Figure 1. Forms of blockchain.

The most common variant is the publicly accessible public permissionless. This is mainly used by crypto currencies. With this form of blockchain, both access and validation (within the framework of the consensus process) are granted to an infinite number of network participants. The protocol is also public so that other coins can be developed based on it (Voshmgir, 2016). A slightly modified variant is the least common private permissionless blockchain, which is a private network but can be freely accessed after prior registration. Any registered user can also validate transactions (Palkovits et al., 2017).

In contrast to the variants explained so far, the validation permissions are restricted to the permitted blockchains. The private permissioned variant represents an in-house solution that is used within a company to increase the efficiency of data management. Only selected network participants receive access and validation options (Voshmgir, 2016). The public permissioned blockchain, also known as consortium blockchain, can be accessed by all or only selected users depending on the specification. The validation, however, is only carried out by selected network participants (Zheng et al., 2017). This blockchain variant is best suited for the e-voting application. For example, all persons from a certain district who are entitled to vote can be defined as users and the voting assistants as validators.

In addition to the two security procedures explained in the previous section (hashing and consensus finding), the encryption of transactions also provides a high security factor for blockchain technology. The asymmetric encryption technique is used most frequently, in which private and public keys are used. Each network participant receives a key pair. The transaction is signed with the private key and then forwarded for verification. In the verification phase, the transaction can be validated and decrypted with the help of the public key (Zheng et al., 2017). With the development of quantum computers, however, the chances of cracking traditional asymmetric encryption algorithms have also increased significantly (Dai, Shi, Meng, Wei & Ye, 2017). To ensure long-term security, the latest state of the art should therefore always be taken into account. For this reason, post-quantum cryptography must be used (Palkovits et al., 2017).

The presented security features as well as the complete verifiability and unchangeability of transactions as well as independence from third parties allow the problems associated with traditional e-voting systems to be solved. Furthermore, the use of blockchain technology fulfils the legal as well as professional and user-specific requirements that are placed on an e-voting system (Perenthaler, Schloßmacher & Windeck, 2018). The extent to which this application scenario is relevant for a software service company will be shown in the further course of this paper.

4. Already available e-voting solutions with blockchain

In times of digitalization, the Internet is firmly anchored in almost all areas of life. A life without the Internet is no longer conceivable in everyday life or in the world of work. The exclusively analogue voting system in Germany seems. It increasingly fails to meet the people's current demands and needs for political participation. However, the introduction of an electronic voting system is difficult. Digital elections must also meet the high standards of a democratic electoral system. They must be secret, transparent, and secure (Bartolucci, Bernat & Joseph, 2018; Hanifatunnisa & Rahardjo, 2017; Marky & Kolosovs, 2018).

4.1. E-voting with blockchain in Estonia

Estonia is a world leader in digital services. The country enables citizens to access 99% of public services online (e-estonia, 2018). One part of this large online offering is e-voting. Estonia is a leading nation in e-voting. As early as 2005, Estonia was the first country in the world to offer an electronic voting alternative (e-estonia, 2018; Solvak & Vassil, 2016; State Electoral Office of Estonia, 2017). In the local elections, voters were able to cast their votes nationwide via the Internet. The success of this world premiere made it possible to implement the e-voting procedure in the country's parliamentary elections and in the parliamentary elections of the European Union (Solvak & Vassil, 2016). However, this new way of voting was initially only sporadically accepted by Estonian citizens. Only 1.9% of voters used e-voting for the 2005 local elections, but in subsequent elections the proportion of e-voting increased significantly (see Figure 2).

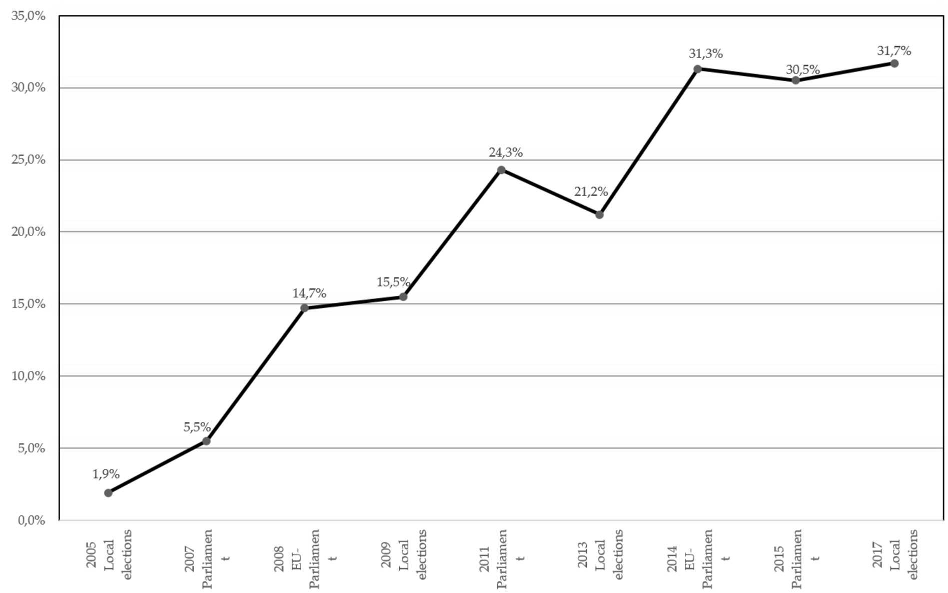

Figure 2. Proportion of e-voting in Estonia.

In 2015, the offer of e-voting was already taken up by almost a third of voters (Solvak & Vassil, 2016; Valimised, 2018). The user-friendly interface of the election website is one reason for this strong increase. Logging in to the Estonian election portal can be done on the computer using an electronic ID card and an appropriate reader. Access via mobile phone requires a mobile ID and a SIM card with additional security certificates (Solvak & Vassil, 2016). Subsequently, a four-digit password must be entered for both variants. In the electoral portal, the software automatically recognizes the voter's constituency and offers him or her the appropriate candidates. After the voter has selected his preferred candidate, he can confirm his choice by entering a second, five-digit password and transfer the vote to the blockchain (Hofmeier & Schwietering, 2017; Solvak & Vassil, 2016). This voting process can be revised as often as desired. Only the last regular vote is transferred to the election results.

However, to make the exchange of votes secure and secret, a tamper-proof and blockchain-based procedure must be used in the background. There are different possibilities for implementation. In the following, the procedure of asymmetric encryption used in Estonia is presented.

As already described in detail in the blockchain section, the principle of asymmetric encryption is applied in this two-stage procedure. First, the central instance creates a key pair consisting of a public and a private key (Bartolucci et al., 2018; Marky & Kolosovs, 2018). The public key is used to encrypt the vote and is issued to eligible voters. To ensure that the public key is individualized to each voter, a random number is encrypted in addition to the ciphertext (Marky & Kolosovs, 2018; State Electoral Office of Estonia, 2017). Afterward, the encrypted voice is signed by the voter with a digital signature (State Electoral Office of Estonia, 2017). The main difference between blockchain-based e-voting compared to previous electronic elections is the storage of the data.

In regular electronic e-voting procedures, the voting website sends the encrypted votes to a single server. Only the government has access to this server to count the votes. E-voting based on blockchain technology offers a much more transparent and secure way of data storage. Here the election results are distributed securely and decentrally in a blockchain network. The network first checks the validity of the vote and then includes it in the blockchain (Kovic, 2017). The encrypted votes are then anonymized by the voting software. They are thus not attributable to any voter (Agora, 2018). With the help of the private key, the anonymized votes are decoded and subsequently counted (State Electoral Office of Estonia, 2017). The transparent character of the blockchain technology allows each voter to view the election results (Kovic, 2017).

4.2. The blockchain start-up Voatz

The new blockchain technology enables a secure and fully electronic voting system. Increasingly, states and companies are recognizing the resulting opportunities and investing in research into the new technology. For example, the small start-up Voatz from Boston (US) is developing a blockchain-based voting platform (Montgomery, 2018). This is intended to enable voters to vote by smartphone or tablet in the future. Voters will be identified by fingerprint or face recognition. The company's platform runs on a public permissioned blockchain, which is particularly suitable for this application. Voatz's future opportunities are also demonstrated by its participation in support programs that promote start-ups with particularly high chances of success (Techstars, 2017). This has already provided the small company with consultants and financial resources. In addition, contacts have been established with large, international corporations. For a small start-up such as Voatz, it is initially difficult to find users for its own solution. Therefore, the software was initially tested in pilot projects with political parties, leading universities, trade unions, and non-profit organizations. This enabled more than 70,000 voters to successfully use the company's platform in various areas (Bowles, 2018). On May 8, 2018, the US State of West Virginia used the company's blockchain technology for the first time in a political election, and the Voatz electoral platform enabled soldiers stationed abroad to vote securely and electronically (Freist, 2018).

4.3. E-voting with blockchain in Sierra Leone

In view of the upcoming elections in 2020, the US State of California is also trying to revolutionize its electoral system. The state has spent more than $130 million to develop new e-voting solutions and to advance research into blockchaining (Montgomery, 2018). Selected countries have already made further progress in development and application. They have proven blockchain-based voting systems and have already been able to offer these in state elections.

During the presidential election in Sierra Leone in March 2018, blockchain technology was tested for the first time in Africa in an election. The national election commission of the West African country cooperated with the Swiss software company Agora. As a result, the votes of 280 electoral centers in a constituency could be registered and counted in a blockchain (Freist, 2018; Kazeem, 2018). After the ballots had been registered and processed as usual, they were additionally recorded in the blockchain of the cooperation partner Agora (Buchmann, 2018). The software then evaluated the votes, and the results were published on the company's website (Kazeem, 2018).

The company developed a voting app for the application area of electronic voting. This first informs the voter about the candidates and provides background information. The app can then be used to vote, and the results can be viewed after the election (Agora, 2018).

Many other countries are currently trying to implement blockchain-based e-elections. Brazil, Denmark, South Korea, and Switzerland also plan to offer blockchain-based e-voting procedures in the near future (Freist, 2018).

4.4. Chances and risks of e-voting with blockchain

Voter turnout in Bundestag elections has shown a negative trend since 1972. Only 76% of those eligible to vote voted in the 2017 federal elections. This is the third worst turnout since 1949 (Bundeswahlleiter, 2018). The proportion of postal voters, in contrast, has risen to a historic high (Marky & Kolosovs, 2018). Electronic voting systems could be the answer to these developments. Today's analogue voting system no longer meets the requirements and needs of voters. Sick voters or voters who are abroad are often not able to participate in the election. With e-voting, the whereabouts of the voter would no longer be relevant. Only an Internet connection is required for participation.

In addition, electronic voting has a mobilizing effect. For voters who do not go to the ballot box for reasons of convenience, an alternative to paper-based postal voting would be created. Another advantage is the transparent character of the blockchain. Every voter can track the counting of his or her own vote into the final result (Kovic, 2017; Moura & Gomes, 2017). The votes would also be counted automatically by the system. The result would thus be available immediately after the election and could not be falsified (Müller, 2017). Moreover, manipulation by individual organizations or institutions would no longer be possible (Welzel, C., Eckert, K.-P., Kirstein, F. & Jacumeit, V., 2017). A further advantage of e-voting is the reduction of the effort involved in an election. For example, the Estonian Government is able to save 11,000 working days per election by using e-voting. Since the beginning of the introduction, even 800 working years have been saved (e-estonia, 2018). However, the most important advantage of a blockchain voting system is its security. The decentralized data storage of a blockchain makes the corresponding election almost completely secure against manipulation.

In addition to these opportunities and advantages, a voting system with the support of a blockchain is also associated with problems and risks. Electronic voting systems have been hacked many times in the past. Not only have such elections been declared invalid, but the hackers were also able to read the political preferences of the voters (Wagner, 2016; Bruer & Perez, 2016). In contrast, current e-voting platforms based on blockchain technology are considered safe. In the past, it was often only a matter of time before a system became vulnerable to hackers. Thus, even when data are stored in blockchains, there is a risk that one day it will be manipulated by new technologies and hacker software. In addition to this security risk, there is also the danger of tactical choices. If a blockchain not suitable for e-voting were to be used, the distribution of votes among the candidates would already be transparent during an election. Moreover, each voter would be able to prove his or her vote to a third party, which could encourage a black market for the sale of votes (Welzel et al., 2017).

Some countries have already failed in their attempts to implement an electronic voting system. They were unable to implement the necessary requirements for an election digitally. Often, past methods were based on central electronic platforms. These were vulnerable to hacker attacks and offered insufficient transparency to the voter (Bruer & Perez, 2016). It was almost impossible for the voter to track whether his or her vote really counted toward the election result (Moura & Gomes, 2017). The new blockchain technology with its decentralized, open, and secure approach to data storage provides a solution to these problems (Müller, 2017).

5. Methodology

The goal of this qualitative-explorative work is to derive recommendations for a blockchain-based e-voting system. To achieve this, a case study approach was chosen as the first stage of the research design as there is no comprehensive systematic research on this topic as of yet. According to the argumentation of Yin (2009), case studies are particularly suitable for investigating novel and complex topics such as the present one.

To derive recommendations from the information collected in the case studies, the experimental methodology of the *Digital Innovation Playbook* was used in the second stage of research design. The process described therein is based on the principles of design thinking. The objective is to explore a topic area, generate a business model for digital services, and finally evaluate the idea. In these three phases, creative techniques are used to work on 25 process elements (Dark Horse Innovation, 2017).

6. Results

The traditional means of casting votes is no longer up to date. Due to media disruptions and time-consuming counting, it harbors potential for errors and security risks. The users' needs for flexibility, efficiency, and independence in voting are not satisfied. The demand for more security and transparency must not be neglected. Replacing conventional elections with an e-voting system based on blockchain technology has the potential to serve voter needs better than conventional solutions (cf. Section 4.1).

This is demonstrated by current megatrends such as connectivity. This term covers the digital networking of humanity, the Internet of Things, and digital platforms (Zukunftsinstitut GmbH, 2018a). The technology of the blockchain (see Section 3.2) is part of the digital platforms and can lead to the reformation of entire industries in the long term (Gartner, 2017). A blockchain-based voting system is also influenced by other megatrends such as mobility. Today is a multimobile age. Society is looking for solutions that solve its problems in real time, conveniently, flexibly, and economically (Zukunftsinstitut GmbH, 2018c). Another megatrend that must be mentioned and is taken into account by a blockchain solution (see Section 3.2.2) is the desire for more security. The goal of more control and more freedom to the same extent is aimed at (Zukunftsinstitut GmbH, 2018b). Social developments lead to a new security structure and a new understanding of privacy. Networking across the entire globe has a particular impact on the security of our personal data and the protection of our privacy (Zukunftsinstitut GmbH, 2018b). Only from these trends and the technologies associated with them can developments such as e-voting and Democracy 2.0 (see Section 3.1.3) be understood.

An important factor for the development of a digital service in the context of Democracy 2.0 becomes clear from the evaluation of voter participation in German federal elections (Bundeswahlleiter, 2017c). The number of non-voters has risen steadily since 1949. A comparison with voter participation in Estonia (see Figure 2) shows that there is a high potential for users of a digital voting solution. A further indication is the continuously rising proportion of postal voters in the German Bundestag elections (Bundeswahlleiter, 2017a). This makes it clear that voters are open to alternatives to conventional voting if they meet their needs.

Potential fields for a blockchain-based voting system are all areas where elections take place, ranging from local to national political elections.

The spectrum of political elections in Germany is broad, ranging from local to state to federal elections which is why block chain technology can be used in many ways, In the Bundestag election 2017, for example, there were 299 constituencies (Bundeswahlleiter, 2017b) and 650,000 election workers (Bundeswahlleiter, 2018). The Bundestag elections in 2017 cost around €92 million, making them the most expensive ever in Germany (Bundestagswahl-2017, 2017).

Non-political votes, such as in associations, in company co-determination, shareholder elections, the collection of customer feedback, or cooperative votes, are also of interest for the service to be developed.

In summary, such a system can be used wherever decisions are made and elections or votes are held. Voters will thus be able to vote flexibly and independent of location, according to their needs. The underlying technology makes it possible to combine security, privacy, and transparency with the desire for greater flexibility. In addition, the electronic form allows efficiency and cost savings to be realized. An electronic voting system must provide a further means of voting in addition to the conventional, analogous method of voting.

7. Implementation

The idea generated in this paper could very well be implemented by a software service company. However, the described solution represents an enormous investment. In particular, the construction of a suitable infrastructure, the development of the software, and the conception of the associated services become very capital intensive. Ideally, the software service company already has a large computer center and thus an important basis for the development of the IT infrastructure. Customer contacts and developers are also available as assets.

When introducing the solution described above, a multi-stage plan would be advisable, which minimizes the risk taken and processes the use cases in ascending order according to their security requirements.

The first step would be an application of the blockchain-based reconciliation software in the internal environment. This could involve management decisions or other case studies. This should act as a proof of concept and show errors in the software before a market test. In this way, the necessary know-how for the next stage of the implementation plan can be gathered—pilot projects with customers. A potential use case in this context would be surveys among customers, which can be carried out with the help of the blockchain solution. The experience gained in this way provides the basis for purchase arguments for customers who organize non-political elections, such as club elections, votes on the articles of association, or shareholder votes. The third step is the step into politics. This should start with local political elections, such as mayoral elections or citizens' referendums. The previous stages form the basis for the final step of conducting political elections at the highest levels with the described software. One objective, for example, would be the federal elections in 2029. The €92 million for the federal elections in 2017 also provide a potential starting point for an attractive revenue model (Handelsblatt, 2017). The solution described depends on fewer election workers than the conventional election system since counting is automated, and more process steps are digitalized. The savings achieved in this way form a basis for negotiating prices.

8. Findings, limitations, and further research

In the political system of democracy, power and government come from the people. The principle has existed for over 26 centuries. During this period, the system has undergone constant development. Over the course of time, it has always been adapted to the changing requirements. In the same way, the system can be interpreted and applied differently today. There are numerous variations that differ in terms of forms of participation and election.

However, the majority of today's population is no longer able to meet the demands of this classic form of democracy. It is faced with growing political dissatisfaction. This is expressed, among other things, in the growing popularity of populist parties. As in previous centuries, the system needs to be adapted to the current demands of the people. Democracy 2.0 now represents a means to solve this problem and to increase the political participation of citizens through direct interaction. Electronic voting systems supported this kind of direct participation through the digital aspect.

However, the introduction of an electronic voting alternative must meet the high standards of a democratic electoral system. Often, institutions have been unable to overcome these hurdles and failed to develop a secure, transparent, and secret voting system on the Internet. However, blockchain technology makes it possible to avoid such pitfalls through a decentralized, open, and secure approach.

A blockchain-based voting software from a software service company should take the following three factors into account: be closely aligned with voter needs, include voter participation as a key measure of acceptance, and be designed as an alternative to traditional voting. During implementation, the greatest possible learning effect should be achieved through a step-by-step increase in complexity while minimizing risks. Thus, starting with internal elections, the aim for Germany should be to achieve the goal of holding Bundestag elections.

The results of the paper are subject to a number of limitations. First, it should be mentioned that the blockchain technology is still in a relatively early phase of development. There are no established standards for certain applications as of yet. For such a data-sensitive application, the software service provider must therefore develop its own blockchain solution.

This in turn involves an enormous amount of time and money. At the same time, attention must also be paid to the latest developments. With the spread of quantum computers, there is a danger that a blockchain-based solution, once developed, which was previously considered secure, will not be optimal in the future.

Moreover, the proposal developed for the software service company only applies to the German market. It is conceivable that other European countries are also interested in such a solution. However, it is certain that no country will outsource the preparation, implementation, and evaluation of its own elections to foreign companies. A country is more likely to develop its own blockchain-based voting system. It could therefore also be that no private sector company would be commissioned to do this but that the states would commission completely state-owned institutions.

Although the suitability of blockchain technology for an e-voting system should not be doubted, the considerations show that further research is necessary. On one hand, the feasibility of the solution should be checked by established companies. The examples presented showed that the e-voting systems were set up by start-ups from the blockchain industry. On the other hand, too little research has been done on the blockchain technology to guarantee the full feasibility of the knowledge gained here. It is therefore recommended to conduct a similar study at a later stage.

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