Technological Forecasting & Social Change 162 (2021) 120397

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Peace engineering: The contribution of blockchain systems to the e-voting process

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ARTICLE INFO

Keywords:
Blockchain
Election
Fraud
Democracy
Peace engineering
Trust

ABSTRACT

In recent decades, several countries have faced political tensions due to citizens' perceptions that their elections are fraudulent; some electors have even chosen not to vote because they believe that the results may be falsified. Thus, electoral fraud is a major issue. E-governance and e-voting are now being used in many countries, some of which are investigating blockchain solutions. The aim of this study is to investigate the potential contributions of blockchain technology to peace on a worldwide level by securing voting systems. Unfortunately, this technology is complex and could potentially generate conflict between actors in elections. Taking an exploratory approach, the authors chose a qualitative method to address this specific topic. Election observers and blockchain experts were interviewed to identify the technology's strengths and weaknesses. Our results emphasize the importance of trust and human factors in the voting process.

1. Introduction

The right to vote is the basis of democratic societies, representing the "empowerment" of individuals. By voting, citizens take part in decision making and can express their views about things such as their professional life (staff representative, member of a work council or trade union, etc.), cities (Mayor), and government (President, representatives of Parliament and Senate) using elections, referendums, or surveys. Distance voting and e-voting solutions via the Internet are beginning to be used and are thereby acquiring a certain legitimacy (Trechsel et al., 2010; Gorbatiuc, 2020). These solutions tend to increase the number of voters, simplify the voting process, and reduce costs by eliminating paper and requiring fewer human resources. However, implementing an electronic voting process implies the use of electronic devices such as computers and smartphones, which provide challenges for elderly voters who are not confident in the use of digital technologies and are attached to the use of a traditional paper ballot. In addition, online voting may generate concerns about security risks, such as election rigging or election fraud committed by governments or third parties. Indeed, hackers have targeted e-voting, inducing fear and anxiety about the process. Interference by foreign governments can cause national political instability, as happened during the 2016 US federal elections (Osgood, 2016) and at the Democratic National Convention in 2016 and in the manipulation of US voters by the firm Cambridge Analytica in March 2018 (Desouza et al., 2019). Furthermore, the media can be manipulated to sway election results in both non-democratic and democratic countries (Coffé, 2016), and rumors can drastically affect both elections and democracies (Teorell, 2010). The fact remains that electors tend not to vote if they believe that the results can be falsified (Vorobyev, 2016).

According to Schuelke-Leech (2018), disruptive technologies can positively impact institutions and public policies. Blockchain technology, launched in 2014, guarantees authenticity, provides transparency, and offers personal privacy protection to individuals—three key factors required for an efficient voting process. Defined as a decentralized platform, the blockchain system allows for peer-to-peer transactions, meaning that data are "*accessible by other peers directly, without passing intermediary entities*" (Schollmeier, 2002, p.101). Several recent researchers have analyzed the impact of blockchain on different sectors such as food distribution (Bumblauskas et al., 2019), the token economy (Lee, 2019), finance (White et al., 2020; Chang et al., 2020), peace engineering (Vesilind, 2006), the sharing economy

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https://doi.org/10.1016/j.techfore.2020.120397
Received 9 March 2020; Received in revised form 6 October 2020; Accepted 7 October 2020
Available online 14 October 2020

(Pazaitis et al., 2017), supply chains (Chang et al., 2019), and e-governance with e-voting systems (Pawlak et al., 2018; Dhulavvagol et al., 2020). A blockchain can secure votes in an e-voting solution by being transparent and controllable (Khazaei and Rezaei-Aliabadi, 2018). Rather than a public blockchain with all nodes able to verify transactions, encrypted nodes are needed in voting systems, with authorization from a central authority (a government) required to make changes to the ledger. A vote is collected and organized into a "block," ready for verification (Pawlak et al., 2018). However, a lack of knowledge about this innovative technology may create obstacles that will prevent adoption of blockchain solutions. In addition, there may be technical issues, such as the need for a powerful and reliable Internet infrastructure, which is not always present in developing countries. Finally, a high degree of trust and confidence is required (Carter and Weerakkody, 2008; Zhou et al., 2020).

The focal point of online participation, a sub-field of e-democracy, is exploring how information communication technologies (ICT) can facilitate democratic goals (Macintosh, 2004). The e-participation concept is based on technology sophistication levels rather than on the theory of participation or democracy (Grönlund, 2009). Nevertheless, ICT tools could, in some countries, create barriers to public participation and be used for non-democratic purposes (Arnstein, 1969). According to Kaynak (2014), technology could help sustain social peace and avoid tensions at the local or international levels. Social peace involves establishing a dialog to maintain trusting relationships and listen to others with respect and non-violence. However, in the case of online elections, social peace could be impacted by violations of voters' rights or misuse of the technology. Here, engineers could play a central role by, for example, proposing technical solutions to prevent conflict or human rights violations and contribute to a more peaceful world (Phillips, 2020). In 2019, Tangorra and Olson[1] defined peace engineering as the "*application of science, engineering, and technology to promote and support peace.*" Engineers should participate in public debates (Bauschpies et al., 2018) and not only provide technical solutions but contribute to citizen diplomacy. They need to address 21st-century concerns such as supporting development of a more sustainable, stable, fair (Catalano, 2006), and peaceful world by moving from a culture of war (Hoople and Choi-Fitzpatrick, 2017) to safeguarding and enriching humanity (Indumathi et al., 2018). To be successful, engineers will need to work at an interdisciplinary and multidisciplinary level (Borrego and Newswander, 2008). Reddy et al. (2018) propose a team-based approach on a multidisciplinary level, reducing the boundaries between application and design to contribute to engineering-driven peace.

The aim of this study is to analyze how use of blockchain systems could secure the voting process by lowering the abstention rate, reinforcing democracy (Vesilind, 2010; Gorbatiuc, 2020), maintaining elections in cases of major health issues such as the COVID-19 pandemic, and reducing interference in electoral campaigns. In addition, it also considers the potential contribution of blockchain technology to peace engineering through secure voting systems. Following a wide review of the e-participation literature, Susha and Grönlund (2012) highlight the lack of research in this area, especially research into the intersection of information technology, political science, and sociology.

To address this topic, the authors raise the following research questions:

R1: How can blockchain contribute to improving or maintaining e-democracy through e-voting solutions?
R2: What are the main constraints to adopting this technology?
R3: Can the results of this study be discussed at political, technical, or social levels?

[1] https://drexel.edu/engineering/news-events/news/archive/2019/March/conversations-olson-and-tangorra-on-peace-engineering/

The article is organized as follows. The introduction presents the research context, followed by a literature review section that discusses the theoretical background of blockchain and voting systems. The third section describes the methodology. As this is an exploratory field, a qualitative approach was selected, using interviews conducted in France and Russia on the specific topic of blockchain and voting systems. A total of eleven experts in both blockchain systems and geopolitics who are involved in e-governance were interviewed to identify the strengths and weaknesses of adopting the technology; the analysis used for the interviews was verified by two academics in the field of geopolitics. The fourth section presents the analysis of our results, while the fifth section discusses those results, structured around the political, technical, and social aspects of blockchain implementation. The final section highlights the study's theoretical and managerial contributions, notes the study's limitations, and offers suggestions for future research.

2. Theoretical background

Implementing an e-voting system implies that mobilized technology is aligned with the principles of democracy. The advent of disruptive technologies such as blockchain could potentially resolve issues faced by actors in the voting processes of today's elections.

2.1. E-democracy and e-voting

The Internet and growth of social media have modified individuals' behaviors (Arora et al., 2019), including citizens' use of e-democracy (Van der Graft and Svensson, 2006), allowing them to take part in decision-making processes (Raikov, 2018). Indeed, these disruptive technologies enhance citizens' participation in politics by (1) facilitating their involvement in civic and political engagement (Pirannejad and Janssen, 2019), (2) changing their engagement from passive to active (Aladwani and Dwivedi, 2018), and (3) using citizens as volunteers to increase the level of voter participation by spreading positive feedback during political campaigns (Grover et al., 2019). In fact, e-government services change the relationship between citizens and politics. Some studies have investigated the factors that influence citizens' attitudes toward and acceptance of e-government solutions (Reddick and Turner, 2012). Rana and Dwivedi (2015) mobilized social cognitive theory (SCT), developed by Bandura (1986), to measure the acceptance of e-government. This theory includes the constructs of self-efficacy, anxiety, and outcome expectations (performance and personal). Other researchers have used the UTAUT (unified theory of acceptance and use of technology) (Venkatesh et al., 2003) and UTAUT2 models (Venkatesh et al., 2012) to measure adoption of e-government (Gupta et al., 2008) by controlling performance expectancy, effort expectancy, social influence, facilitating conditions, Hedonic motivation, price value, habit, behavioral intention, and use behavior. Performance expectancy is key to understanding the degree to which individuals believe that using e-government services will help them improve their performance (Shareef et al., 2011). Other studies have analyzed the impact of trust on the adoption of e-government services (Gefen et al., 2005) and perceptions regarding the security of the relationship between e-government and its citizens (Carter and Weerakkody, 2008). E-democracy includes the concept of online participation and online voting (Macintosh and Whyte, 2008). This study focuses on online voting or e-voting. The concept of e-voting involves use of electronic devices (Svensson and Leenes, 2003) segmented into two distinct systems: (1) electronic machine voting (optical scan machines), which is implemented in polling stations mainly to simplify vote count, and (2) electronic voting, which enables distance voting (Zissis and Lekkas, 2011) using devices (smartphones, computers, tablets, etc.). Several countries have used e-voting solutions for primary (US), national (Estonia), or municipal elections (Switzerland) in recent years, with results and impacts that vary by country (Nemeslaki et al., 2016). Indeed, some countries have noticed a spectacular increase in the

number of voters, such as in Switzerland or Estonia (Germann and Serdült, 2014). However, the results were not as positive in the United Kingdom (Henry, 2003) and Dutch elections (Allers and Kooreman, 2009), and, after many trials, Norway has decided to withdraw its e-voting system (Saglie and Segaard, 2016). Adoption of an e-voting solution is directly linked to the size of the country and the number and profile of voters. E-voting could attract voters who might not vote without this provision (Chondros et al., 2019), such as citizens with mobility issues (depending on their ability to use electronic devices), expatriates, or digital natives (Powell et al., 2012). Nevertheless, the key pillars of democracy are authenticity, legitimacy, and truthfulness, and e-democracy should enhance these. Thus, e-voting faces many challenges, such as security, transparency, and privacy (Willemson, 2018). In terms of security, the rise in cyberattacks, particularly those emanating from states (or state-sponsored groups) and external manipulation during electoral campaigns, has been one of the main security issues, and measures to guard against these must be integrated into the process. Data exchanges must be encrypted and authenticated, and the e-solution should be robust enough to prevent any modification of the final results announcement (Heiberg and Willemson, 2014). In traditional voting systems, voters' ballots are usually placed into a transparent ballot box. At the end of the election process, citizens can count the ballots and verify that the election procedure was executed correctly (Gritzalis, 2002). Thus, certification authorities must guarantee the transparency and accuracy of counting e-votes by ensuring that e-voters' ballots are stored in a trusted environment and no one can access or modify them or determine the election's outcome before the protocol is terminated. Finally, privacy is one of the fundamental obligations of a voting system, protecting citizens from fraudulent access to their personal information such as the content of their vote or profile, including their address and e-mail. Based on Osgood (2016), e-voting systems have been plagued with voting fraud, including technical and security vulnerabilities such as a lack of transparency and accidental or intentional errors when recording votes (Bishop and Wagner, 2007), or the installation of a malicious code that can steal votes without detection (Qi et al., 2017). E-voting requires the voter's confidence in government, politicians, legislators, and the systems developers in charge of technology implementation (Aljarrah et al., 2016). The concepts of trustworthiness, trust in the Internet, and trust in government have appeared as significant factors in the intention to use an e-government service (Levi and Stoker, 2000).

Thus, trust is a critical construct for adopting e-voting solutions, segmented into two parts: trust in the body represented by the official authorities, governments, and control audits, and trust in the tools, including the Internet, software, or blockchain technology (Carter and Weerakkody, 2008). As headlined in Gorbatiuc (2020),*"one small step for e-voting, one giant leap for democracy."*

2.2. e-democracy in the face of the worldwide pandemic

The crisis brought about by COVID-19 has highlighted issues worldwide regarding the right to vote, as several countries were obliged to postpone elections, including Bolivia, Ethiopia, North Macedonia, Serbia, Sri Lanka, and Syria. Other countries, including the United States, have considered alternatives such as postal voting, which was used in Poland for the presidential election in June 2020.

It is not the first time that external events have directly impacted elections. Some political specialists segment these events into types, such as climatic events (Arnold and Freier, 2016), terrorism situations (Montalvo, 2011), or natural disasters (Carlin et al., 2014). With COVID-19, many countries' political systems have been affected through the suspension of legislative and parliamentary activities, isolation and even death of politicians, and postponement of some elections. However, elections cannot easily be canceled or postponed. Elections in Israel in March and South Korea in April were held using special polling stations managed by medical staff, while in France, the second round of municipal elections was postponed. In the US, 16 states have delayed their presidential primary elections while some senators have introduced legislation to expand postal voting and adopt other new procedures for November's presidential election (Kousser et al., 2020). The COVID-19 pandemic could have a direct impact on the US presidential election (Johnson et al., 2020). Oxford Analytica[2] notes that in some countries, election delays could push some leaders beyond their constitutional mandates, creating a legitimacy deficit, while in other countries, leaders with autocratic tendencies may take advantage of the crisis to remain in their positions longer. The results of some current empirical studies have even shown how COVID-19 has affected voting behavior by returning candidates already in place (Leininger and Schaub, 2020). Due public meetings being prohibited, the democratic process is also under threat, adding to the difficulty of reaching voters; however, the main concern for both individuals and politicians seems to be managing the COVID-19 crisis rather than holding elections. Nevertheless, in the case of a pandemic, the usual methods of governance need to be revised and alternative solutions found. Indeed, ICT could provide real-time information and guidance to countries and governments that face problems arising from the COVID-19 pandemic (Pathan and Thakur, 2020), as has already been done previously via the online parliamentary process in the US Senate in 2001 (Kingham, 2003). Wider use of e-voting, especially implementation of a blockchain-based voting system, could achieve secure elections without requiring too much voter effort. However, a secure voting system must comply with the following requirements (Dimitriou, 2020): (1) Ensure the privacy of voters' identities, making it impossible to link a vote to a voter; (2) Accurately count all valid votes; (3) Identify and remove all potentially invalid votes; (4) Verify the voters' legitimacy to take part in the election; (5) Ensure voters are only able to vote once and, finally, (6) Ensure results are not be disclosed before the end of voting to avoid influencing the remaining voters.

2.3. The blockchain concept and e-voting

2.3.1. Blockchain concept

A blockchain is a set of blocks composed of valid transactions working in a peer-to-peer, decentralized way. In a blockchain system, any node can start a transaction that can be spread to all nodes inside the network. To prevent non-repudiation, a digital signature is used to verify the identity of a user (the node) and certify their activity within the blockchain; all other nodes can control the signature. Once the transaction is validated, the hash function is mobilized to add the block to the blockchain in a tamper-proof way (Mohanta et al., 2019). A hash function can be defined as a mathematical function that converts a numerical input value into another compressed numerical value to check data integrity and provide a solution to password storage (Damgård, 1989). Indeed, users are protected against potential intruders, as they are only able to access the hashes of passwords (Bellare et al., 1996). Thus, use of cryptographic hash functions for message authentication has become a standard approach in many applications, particularly internet security protocols, and is already well used in the e-voting process (Rogaway and Shrimpton, 2004). Blockchains can be segmented in three ways: (1) the public blockchain, visible to everyone on the Internet; anyone can verify and add a block of transactions to the blockchain (Xu et al., 2017); (2) the private blockchain, visible to everyone on the Internet, but only a few people can verify and add transaction blocks (Dinh et al., 2017; Roh and Lee, 2020); and (3) the consortium, composed of organizations or groups that are the only ones able to access, verify, or add blocks (Peck, 2017).

[2] Oxford Analytica. COVID-19 election delays could dent democracies. Emerald Expert Briefings.

2.3.2. Development and acceptance of blockchain solutions

The development and acceptance of blockchain relies on specific institutional factors, market structures, and technical aspects (Janssen et al., 2020). In terms of institutional factors, to adopt blockchain as a relevant governance solution, it is necessarily to remove the potential cultural resistance from individuals or companies and demonstrate all its benefits (Ølnes et al., 2017). Regarding market structures, blockchain technology requires a great level of computerization (Kshetri, 2018). It requires technical aspects that are enforced, secured, and mastered. However, blockchain can be beneficial in some disruptive technologies such as the Internet of Things, where most of the application architectures are based on a centralized system. The use of blockchain can help avoid potential issues related to trust management and security (Lin et al., 2017). The concept of blockchain 1.0 first became popular in Fintech with the emergence and development of cryptocurrencies (e.g., Bitcoin). Today, blockchain 2.0 is used in a wide range of businesses such as healthcare (Kaur et al., 2018), notary, transport, supply chains, E-business, and government (Mohanta et al., 2019). Depending on the domain, blockchain can address specific needs. In the healthcare industry, for example, one of the main problems relates to privacy concerns, an issue blockchain can solve. From the perspective of legal services, this technology preserves both the security and privacy of transactions related to legal contracts across jurisdictions (Giancaspro, 2017). An intelligent transportation solution based on blockchain technology can increase security and data privacy and improves the system's efficiency (Yuan and Wang, 2016). In supply chain businesses, blockchain integration ensures the transaction's authenticity and the traceability of products (Nakasumi, 2017). In e-business, blockchain use enhances the feeling of security and trust for customers involved in online shopping and allows creation of trusted data marketplaces (Roman and Stefano, 2016). Finally, within government, blockchain solutions could provide citizens with better quality and transparency of and accessibility to services by improving information sharing and protecting them from cyberattacks (Hou, 2017).

2.3.3. Blockchain and governance

Research of blockchain use in governance emerged in 2015, and since 2017, interest in this topic has dramatically increased (Casino et al., 2019). Blockchain-enabled technology can improve governmental data handling by disintermediating transactions, thereby reducing the opportunities for corruption. In this domain, elections and voting systems are the most promising areas for implementing blockchain. One of the concerns about e-voting systems are their centralized designs, which damage the public's trust in the voting process (Moura and Gomes, 2017). Blockchain developers and researchers have identified voting process issues where solutions are needed: a) public verifiability—the public's ability to verify the entire process and election results; b) individual verifiability—the ability of voters to verify their voting, for example, through their ballot; c) auditability—the ability of a third party to audit the results of an election; d) anonymity, e) transparency—the ability of blockchain to guarantee the openness of the voting procedure (Hardwick et al., 2018; Liu and Wang, 2017). Adeshina and Ojo (2019) discuss two emerging streams of research on blockchain applications in e-voting. The first stream analyzes the use of blockchain for e-voting as a process, such as blockchain-based e-voting, which was launched in Moscow in 2014. The system uses a centralized Oracle database, with 92 million votes cast on a wide range of subjects (Kshetri and Voas, 2018). The other stream looks at the use of blockchain for non-intrusively supporting e-voting; in other words, supporting voting processes as a trusted third party involving the three main actors in elections: (1) all eligible voters; (2) organizers in charge of the election, who verify and record eligible voters' information, and interact with voters during the election; and, finally, (3) the inspectors who ensure the limitation of the organizers' power (Liu and Wang, 2017). Blockchain-based e-voting can ensure part of the job usually done by organizers and inspectors using decentralized, anonymous, and transparent protocols, as the system grants self-tallying (Adeshina and Ojo, 2019; Liu and Wang, 2017).

2.3.4. Blockchain applications of E-voting solutions

The remote e-voting protocols of BitCongress offer frameworks to enforce distributed decision-making. Sovereign and StakeWeighted Voting provide proof of identity and use BitShares (BTS), a token, and web-based version of the Bitshares wallet, while the Boulé ecosystem uses BOU tokens. Most of these solutions need to use consensus algorithms to agree on a decision. Sovereign and Boulé use a proof-of-work (PoW) algorithm as a consensus protocol. StakeWeightedVoting and Sovereign are open sources, so users may trust these systems because they can see the code (Çabuk et al., 2020). New and emerging blockchain systems based on Crypto-voting focus on confidentiality and anonymity, such as Zcash1, a public blockchain system that implements a system for privacy protection. Agora is a voting platform for digital democracy based on a public blockchain and a sharing mechanism that protects the voter's privacy; this system was applied in 2018 as a test in elections in Sierra Leone. The concept of digital democracy is the main focus of the Coalichain project, which attempts to create an ecosystem with interactions between voters and representatives (Çabuk et al., 2020). A crypto-voting system uses a permissioned blockchain and can therefore grant control while maintaining anonymity and confidentiality (Helliar et al., 2020). The choice of such a system is based on a requirement for the safety and reliability of voting results and the need of all actors (voters, organizers, candidates, observers) to verify information in the stages of the voting process (Fusco et al., 2018).

2.3.5. Blockchain benefits for e-voting

Blockchain-based technology for e-voting provides an open-source, peer-to-peer, decentralized, and independently verifiable system, which guarantees confidence, something that is imperative for voters and election organizers (Casino et al., 2019). Content introduced into the blockchain is considered secure and immutable, which could be beneficial for implementing online voting solutions (Khan et al., 2020).

Indeed, governments can maintain a favorable voting environment by proposing a simple and secure solution using a public hash blockchain. First, citizens enter their ID number and username on a blockchain to an external identity verifier via encrypted data. Then, the unique ballot received should be completed and sent to the blockchain-based ballot box. After the election, each user can audit the results of the vote through the open-access data on the blockchain (e.g., AgoraVoting, 2016[3]; BitCongress, 2016).[4] Thus, blockchain can create a platform for public verification and audit rather than this being done by dedicated institutions (Pawlak et al., 2018). Although blockchain solutions are not able to protect against every kind of manipulation (Khan et al., 2020), their introduction into electronic vote management could provide valuable alternatives to actual electronic voting systems. The open-source peer-reviewed software must be secure, honest, and guarantee free and independent results, thereby increasing trust (Noizat, 2015).

3. Methodology

To investigate the potential contribution of blockchain technology in voting systems to peace engineering, a qualitative study was conducted with experts on geopolitics and blockchain. Respondents were interviewed in 11 semi-structured interviews in January and February 2020, using the concept of data saturation (Table 1). The interviews lasted between 40 and 55 min; three were administrated face-to-face (France) and eight remotely.

[3] AgoraVoting (2016) agoravoting.com.https://agoravoting.com/

[4] BitCongress (2016) www.bitcongress.com.http://www.bitcongress.com/

Table 1
Sample.

N°	*Country*	Experience
1	*Russia*	Observer in elections, including e-voting, experience with e-voting and m-voting
2	*Russia*	Observer in elections and IT specialist, test of blockchain-based e-voting
3	*Russia*	Observer in elections and use of technology, experience with all technologies
4	*Russia*	Observer in elections and use of technology including blockchain, experience with all technologies
5	*Russia*	Observer in elections and use of technology including blockchain, lawyer
6	*France*	Blockchain and geopolitics
7	*Russia/France*	Blockchain use in economics
8	*France*	Blockchain use, e-government, digitalization of society
9	*France*	Blockchain use, e-government, digitalization of society
10	*France*	Blockchain use, e-voting for decision making in any context, not politics
11	*France*	Blockchain development, use in cryptocurrency

3.1. Sample

The interviewees, all professionals, were selected according to their level of knowledge and involvement both with blockchain technology and e-voting processes. Eleven experts were interviewed, five in Russia, and six in France. The Russian respondents had rich experience with the use of innovative technology in the context of Russian elections. Drawn from different professional backgrounds, they represent the voter rights movement GOLOS, a Russian organization for the public observation of elections. This organization trains observers, supports the work of the federal hotline and online services, provides legal assistance to voters, participates in improving the electoral system, and conducts long-term and short-term election observations. They had the opportunity to observe the use of blockchain technology in the 2019 municipal elections in Moscow. The French respondents were all blockchain experts who were confident with the e-governance topic, including voting systems. Four of them were technological experts (professional developers, founders of startups and associations) in several areas including the blockchain domain; some of them had an academic background. The two other French respondents were members of the ATENA forum, an association at the convergence of digital, business, and higher education. For confidentiality purposes, the names of all respondents have been removed from this article. Most respondents were males (91.6%) and averaged around 35 to 45 years old.

3.2. Interview guide and data analysis

The interview guide was developed around four themes: (1) peace and technology; (2) the organization of voting processes (identifying the key players, typical procedures without and with technology); (3) election concerns and conflicts (during and after the voting process, with and without the use of technology, technology's ability to solve some of the issues); and, finally, (4) blockchain and elections (application of blockchain, how it works, benefits and blockchain issues in election processes).

The recorded interviews were transcribed and analyzed using the coding method recommended by Gillham (2000). To ensure internal validity, two authors independently analyzed the interviews by identifying a list of categories and subcategories within the four themes, comparing them, and agreeing on an analysis grid. The results were then validated by two academic experts on geopolitics (male, both between 40 and 45 years old) from French universities.

4. Results

The purpose of this study is to analyze the potential contributions of blockchain technology to the voting process and investigate whether it can (1) contribute to peace, (2) improve the election process, (3) remove some concerns and conflicts, and (4) involve more citizens in the democratic process.

4.1. Contribution to peace

Some interviewees first reacted negatively to the possible contribution of technological innovation to peace, believing that engineers contribute more to war than to peace, while others considered technology a neutral tool.

"…technology can be used for good and bad things…" (Interviewee 10). "…*Technologies themselves are neutral; they probably can provide something to individuals if they are not used for propaganda purposes…*" (Interviewee 2). A paradox was highlighted concerning the link between technology and democracy. Indeed, some interviewees considered that democracies are more confident in the use of technologies: "…*when a society is democratic and fair, they are ready to use information technologies…*" (Interviewee 1).

Nevertheless, technology is not considered a vector of democracy for non-democratic countries. In such societies, technology can be used to collect information about citizens, control them, and even grade them by implementing, for example, a social scoring system depending on their behavior. Some technologies can also be used to manipulate or violate privacy: *"… social scoring, having the ability to score people so that they can incentivize people to act in a certain way…", "…the technology being used to manipulate people…as a tool of oppression…*" (Interviewee 10). The technology could also lead to conflicts, for example, with environmental issues impacting the social peace. Indeed, regarding sustainability, technology has a direct impact on climate change, as much energy and many resources that damage the planet are required:*"…technology can impact this planet…"* (Interviewee 8), *"…and the digital process is a cost for the planet…we know it is not sustainable…"* (Interviewee 8). Finally, technology can also support peace: *"the use of technology provides benefits that can contribute to peace"* (Interviewee 3).

4.2. Benefits of the e-voting process

4.2.1. Organization of traditional voting processes and actors

The voting process includes institutions, procedures, laws, and, of course, the involvement of citizens. Interviewee 2 identified three key players—candidates, administration, and voters: *"…there are three groups of actors whose goals are very different: candidates…election administrations…voters…"* (Interviewee 2). Nevertheless, development of e-voting solutions, whether they use blockchain technology or not, involves introducing new players, making the process more complex: *"… programmers, developers of algorithms, server owners… experts in security…website developers…administrators…each actor has its system of values and interest…"* (Interviewee 3). The voting process, implemented within a democratic country's needs, must be truthful and aligned with its laws: *"…universal and equal rights to vote, everyone has the right to one vote, which excludes fake ballots*." (Interviewee 4). The traditional process consists of several actions: *"…The voter comes physically to the polling station and votes, picks up ballots, select[s] one…put[s] it in the ballot box. Observers make sure that the ballot is correctly registered…"* (Interviewee 5).

4.2.2. Benefits of technology in the voting process

Digital technology, such as e-voting solutions, plays a key role in a country's political infrastructure. It must be understood and adopted by citizens before moving from being e-governance to an *"…e-culture…"* (Interviewee 2). Several benefits were mentioned by interviewees. First, digital technology can increase the level of participation:*"…it can seriously increase the involvement of citizens who want to participate in decision-making…,"* "*… the development of a separate mobile application allowing [citizens] to participate in public affairs such as elections/voting…"* (Interviewee 5); "*…with electronic voting, the number of participants is growing quickly…*" (Interviewee 3). Second, transparency is essential to a democratic election: *"…it's good that technologies are transparent… Transparency is one of the principles of voting rights…"* (Interviewee 1); *"… the society and election participants should be able to control the work of election administration…"* (Interviewee 4); *"…should be a transparent implementation…"* (Interviewee 5). Third, online voting solutions need to provide a high level of security: "*…The observers in Russia and our organization welcome the use of the public service of e-governance because it is quite secure…*" (Interviewee 1). Fourth, e-voting could help reduce the level of fraud: *"…KOIB (Russian optical scan voting system) is the first technology that came to the Russian elections …it insured against fake ballots…as the adding of fake ballots is impossible…"* (Interviewee 2). Fifth, technology could be a sustainable solution: "*…we refuse to use paper as we have electronic voting…*" (Interviewee 3). Finally, the use of distance voting and e-voting is considered convenient by both voters and the administration: *"There is convenience…for voters and the election commission…"* (Interviewee 1). Trust is considered key for adopting innovative technology: "*…if people decide to use technology, it's because it will increase the level of trust in society…"* (Interviewee 1); *"First, they must make the elections themselves democratic with a high level of trust, and then add innovation…"*(Interviewee 3); *"…outgoing from the standpoint that the voter is fully confident in the system…"* (Interviewee 11).

4.3. Concerns and conflicts in the voting process

The interviewees did not believe that use of technology could eliminate existing concerns; rather, some of them considered that technology would generate additional fears and conflicts: *"…Technology is just something causing new concerns…"* (Interviewee 1); "*there is no border, there is no law, no security, nothing…*" (Interviewee 11). Indeed, transparency, one of the benefits, could be also regarded as a violation of the basic right to vote process protection, as elections should be based on: "*…voluntary voting and secrecy of the ballot - no coercion to voting and making a certain choice…*" (Interviewee 4); *"….All the technologies that allow you to trace can break a very important thing called the secrecy of the ballot…"* (Interviewee 3);*"We should find the golden mean of how to ensure transparency and make sure that these votes have been received and the anonymity…"* (Interviewee 5); "*Representatives of electoral systems are concerned about the loss of visibility/ transparency and control over the voting and results…"* (Interviewee 4).

Trust in technology and, equally, trust in government, are the biggest issues surrounding the voting process: *"…the problem with the electronic voting system is trust…I am in the world of technology I have no trust…", "…in countries like France, like Russia considered old countries (weight of history) … The trust of the citizen is not automatic…"* (compares with Estonia) (Interviewee 6). Another concern raised is about potential hacking: *"Representatives of electoral systems are concerned about hacking…and external interference in voting and results…"* (Interviewee 4). Finally, according to the interviewees, use of technology could allow manipulation and falsification of the results: *"In the future, e-voting in regional and federal elections will provide an opportunity to falsify, potentially in an unlimited volume without special risks of being caught, without the ability to fix falsification in a way that is understandable to society…"* (Interviewee 4).

4.4. Blockchain and elections

First, blockchain is considered a technology: "*…just a tool…"*(Interviewee 11), used in different sectors of activity such as Fintech and e-health: *"…blockchain technology has a lot of possible applications…the most obvious ones are related to payments…"* (Interviewee 7); *"…the bigger branch of the function is e-health…"* (Interviewee 8). A public blockchain is transparent and visible to everyone in cases where secrecy is not required. Transparency means access to information for everyone who can use the technology: "*…transparency is a good thing and a blockchain is a tool that could enable more transparency in public affairs…*" (Interviewee 10). For election purposes, a private blockchain is more appropriate. We observed two different points of view regarding blockchain and e-voting systems, depending on whether interviewees were experts in blockchain or geopolitics. Indeed, the blockchain experts were more focused on all the advantages of this disruptive technology:*"… secure to make it immutable and make it safe so that we can guarantee to citizens that they can use the system without being afraid…"* (Interviewee 9). In contrast, the geopolitics experts found there was no difference between e-voting procedures with or without blockchain technology, as the people in charge of implementing it are the same: *"At the same time, to any technical specialist, including myself, it is clear that this blockchain is in the same hands of the election administration. There is no difference…"* (Interviewee 2).

4.4.1. Benefits of blockchain use in elections

Implementing a blockchain to meet e-governance goals involves removing the human factor from elections to avoid misuse or mistrust (Ondrisek, 2009) and replacing it with smart contracts: *"… for example, smart contracts governing voting procedures…*" (Interviewee 7). The main role of a blockchain in an election process is to decrease the level of fraud: *"To guarantee the honesty of voting during the election campaign of Moscow, it was indicated that a blockchain would be used, which would protect the voting process…"* (Interviewee 2). The information included in the blockchain cannot be altered, which is the most important benefit of this technology for elections:*"…you can be sure in most cases that once the change has been submitted to the ledger it's impossible to modify it, to tamper the result…"* (Interviewee 7). Interviewee 11 considered decentralization one of the key characteristics of blockchain: "*…there is no boss…*". Some countries had implemented reliable and efficient architecture: *"… the Estonian system is based on a blockchain that works without proof of work and therefore is very effective…much faster and more efficient in energy consumption…*" (Interviewee 6).

4.4.2. Disadvantages of blockchain use in elections

Nevertheless, this technology is quite complicated: *"…mechanisms, encryption/decryption algorithms are not understood even by specialists…"* (Interviewee 4), and traceability needs to be demonstrated: "*The encryption of the vote should be carried out by the user so that the vote is sent to the blockchain in an encrypted form … but how can you verify that this vote was from him/her and was not changed on the way to the blockchain…"* (Interviewee 5). The technology is not sufficiently well understood by all: voters and observers need increasing levels of technical knowledge or background: *"…observers must acquire the necessary skills and competencies in technology…"* (Interviewee 3). Interviewee 2 questioned the fact that transparency could be used as a marketing message or for propaganda purposes but that this is perhaps far removed from reality: *"…An example in Moscow when voting using blockchain there were no open procedures at all. People went to the computer, voted, and then the procedure was unclear…"* (Interviewee 2). Finally, storage of information could have a negative effect in the case of elections: *"…as can you be sure regarding the integrity of storage and that nobody can access…"* (Interviewee 9).

5. Discussion

The aim of this paper was to explore the contribution of blockchain to peace engineering when applied to the voting process. The authors were able to draw on the broad experiences held by the experts interviewed in the political, social, and technical aspects of blockchain. Our results were organized following Susha and Grönlund's (2012) approach to fill a gap in interdisciplinary research.

5.1. Political aspect

The authors considered a political paradox relating to the use of technology such as a blockchain and its contribution to democracy and social peace in ensuring the transparency of election processes. For example, it could worsen the current political system in a non-democratic society by increasing the level of control over the population (Adeshina and Ojo, 2019; Shahzad and Crowcroft, 2019; De Filippi, 2018; Hofman and Novin, 2018). Indeed, one of the main concerns highlighted during the interviews was the potential integrity of the holder of the technology. The findings are consistent with previous research in that e-voting solutions, even those based on blockchain technology, can be used as a tool of political oppression (Desouza et al., 2019). Indeed, the organization of elections requires use of a private blockchain, with transactions available to a limited number of actors (Dinh et al., 2017; Roh and Lee, 2020). Experts raised the alarm concerning the opportunity for governments to implement a social credits system and trace voters (Nakasumi, 2017). This finding is aligned with other studies (Xu et al., 2018), as the benefits brought about by transparency can also violate the right to ballot secrecy, as criticized in the Estonian voting system (Willemson, 2018). Several researchers have discussed the relationship between use of technology and politics based on trust. According to our interviewees, trust is considered key for the acceptance of disruptive technology such as a new type of voting method. In the case of elections, trust has two dimensions: trust in the technology regarding its functionalities and trust in the governments or institutions in charge of the election; both are interconnected (Welch et al., 2005). Trust in the government, system, and infrastructure are essential when implementing such a technology (Vorobyev, 2016). In fact, without a trustworthy democratic solution, citizens will be unable to trust the tools proposed by institutions. Nevertheless, some studies emphasize the fact that the adoption rate of blockchain solutions could be higher in cases where individuals have greater trust in the technology than in the government (Queiroz and Wamba, 2019; Hughes et al., 2019). Also, this trust in government, especially in Western countries, could mainly result from the balance of power between the state and the legal institutions in charge of making sure laws are observed (Atzori, 2015). Nevertheless, mistrust can be reinforced where national issues, such as political instability, vulnerable electoral processes, and compromised governance occur (Shahzad and Crowcroft, 2019). This feeling of mistrust is not, however, limited to non-democratic systems (Hofman and Novin, 2018; Zheng et al., 2018; Shahzad and Crowcroft, 2019). As emphasized by the interviewees, the benefits provided by blockchain and remote voting, such as a higher level of participation, might tempt institutions or governments in charge of organizing elections.

5.2. Technical aspect

Second, blockchain can be regarded as a peace engineering solution. Based on our interviews, blockchain technology can increase security. The security aspects include encryption, transparency, confidentiality, and trust (Çabuk et al., 2020). Indeed, the use of blockchain as a security tool in the voting process could contribute to reducing hackers' attacks (Hou, 2017), as encrypted data are stored securely (Kochovski et al., 2019). Our findings confirming the importance of transparency for all stakeholders are consistent with previous research (Sahonero-Alvarez, 2018; Khazaei and Rezaei-Aliabadi, 2018). Nevertheless, there remains a technical paradox in terms of transparency and confidentiality (Bernstein, 2012). In the field of auditing, for example, blockchain adoption remains a dilemma, as businesses must also manage the balance between transparency and confidentiality (Wang and Kogan, 2018).

The key topic of trust in technology highlights the importance of innovative technology acceptance (Lin et al., 2017; Aladwani and Dwivedi, 2018). Many researchers note that blockchain provides "trustless" systems (De Filippi, 2018, p.267); in other words, trust is no longer essential (De Filippi, 2018; Hofman and Novin, 2018). However, individuals will need to have trust in mathematics-based technology (Smits and Hulstijn, 2020; Risius and Spohrer, 2017; Menon and Bhagat, 2020). There are also some important issues, such as software bugs. Indeed, due to the technology's complexity, solving bugs is more complicated (Bistarelli et al., 2019), and, should there be an attack, it is more difficult to trace the hacker (Efanov and Roschin, 2018). Finally, observers have noticed that, due to the technology's complexity and their lack of knowledge, individuals are unable to verify transactions; in fact, only a few professionals have a clear understanding of how it works. Hence, for Smits and Hulstijn (2020), trust is directly linked to the level of understanding of the technology.

5.3. Social aspect

Finally, in addition to the political and technical aspects, our interviewees raised some social issues, such as participation in elections. Indeed, participation could present another paradox, as some experts consider that the transparency offered by blockchain could enhance the level of participation, whereas others consider that traceability could be a barrier to adopting such a technology. In previous research, the social impact of blockchain technology was examined in terms of providing easier and better access to governmental services, including voting (Çabuk et al., 2020). In this case, a blockchain could be considered an innovative tool for improving the social relationship between citizens and state. All interviewees agreed that acceptance and use of blockchain technology in public affairs, including in elections, is necessary. Nevertheless, according to election observers, before blockchain technology is applied to a national election, it should be tested on less impactful undertakings, such as local or regional elections. Reijers et al. (2016) investigated blockchain governance in connection with social contract theories. Our interviewees expressed concern about the potential use of such a system as part of a kind of social credit system, as has already been implemented in China (Xu et al., 2018), where citizens' activities are analyzed and the results are used to reward or punish, depending on the behavior.

As indicated by the interviewees, blockchain is a complex technology, which means that only a very few people can understand how it works, leading to a kind of technical "elitism and centralization" (Atzori, 2015, p.27), increasing the social gap between skilled individuals and others. This finding confirms Shahzad and Crowcroft's (2019) study, which assumes that modern voters are supposed to be highly educated, informed about their fundamental rights, aware of the technology, and, finally, have access to an Internet connection.

6. Conclusion, contributions, limitations and future research

At present, due to the COVID-19 crisis, remote elections (e-voting) have become a trending topic for maintaining democratic practices and, consequently, social peace. The purpose of our study was to investigate, using an explanatory approach, whether blockchain technology can be considered to contribute to peace engineering in the context of elections. According to our interviewees, this disruptive technology could contribute to developing a peaceful society, offering social and political equality, justice, and integrity. Thus, when it is used to protect e-voting, and, therefore, to protect democracy, blockchain becomes an

illustrative case of a peace engineering tool (Sahonero-Alvarez, 2018).

Therefore, the use of blockchain-based solutions in e-governance, including e-voting, hold great promise for researchers and managers. Based on the present study, both theory and practice can use the lessons learned.

6.1. Theoretical contributions

On the theoretical level, this research proposes two dimensions of the blockchain concept in elections: explicit and implicit. The explicit dimensions describe the technical aspects of the blockchain: all the experts interviewed could clearly explain the principals of this technology. In this way, this paper addresses the first gap—most of the research done on blockchain is technology-focused, suggesting new protocols, and does not analyze in depth the advantages/drawbacks of the system for decision-making. Thus, as indicated by Risius and Spohrer (2017), there is a lack of conceptual research on blockchain topics. The implicit dimensions of blockchain in elections present the meaning of the benefits and/or constraints that the study participants could develop out of their knowledge and/or experiences. Following these meaning-making patterns, this study addresses another gap and can propose a generalized structure of the blockchain concept in elections. Moreover, existing papers on e-voting do not examine user acceptance of blockchain solutions. Thus, our purpose was not intended to deal with the technical aspects of blockchain but to analyze the views of experts at a user level to identify potential motivations or barriers for acceptance of such a technology.

6.2. Managerial implications

The perspectives of both blockchain experts and election observers exposed a range of current issues that can serve as examples of lessons learned in implementing blockchain-based elections and help advance several changes.

Change 1. : Distinguishing between information campaigns and government propaganda.

As we learned from study participants, public trust in technology can be destroyed to some extent by misuse of blockchain rhetoric in government campaigns (further control of voters). Indeed, due to previous negative experiences, when technology and, consequently, blockchain systems, are promoted by governments, most will consider it a propaganda tool. Thus, when using blockchain technology, governments or institutions must communicate the control processes that are in place to guarantee confidentiality and anonymity.

Change 2. : Close collaboration of key players

Based on previous experiences, participants claim that, for successful implementation, developers, governments, and institutions developing and using blockchain technology for election purposes must be able to promote and be transparent about the technology involved and share their knowledge with others (Xiong et al., 2019). Indeed, close collaboration between all actors in the process, especially in more fragile political systems, could contribute to wider and faster adoption of the technology, as all key players in the election process, including voters, must trust e-voting solutions.

Change 3. : Active involvement of citizens in the development process.

Another lesson learned demonstrates that today, citizens are not considered when the technology is proposed. Implementing new technology requires the approval of the primary actors: a country's citizens. Thus, they must be involved in the decision-making process. For countries such as Estonia that have already ventured into e-governance by digitalizing some of their services, public acceptance of blockchain technology may be easier to achieve. Other countries, which are not as advanced with their digitalization programs, could face education issues given that knowledge about and understanding of such technology may be poor. Therefore, appropriate training using a marketing campaign must be adopted to resolve this issue and prevent technical elitism, as described by some authors.

6.3. Limitations and future research

This paper has some limitations relating to the sample that offer opportunities for further research. First, only experts with similar levels of knowledge regarding the technology were interviewed; therefore, no moderating effect of their country of origin could be identified. Second, voters were not included in the study; therefore, quantitative research should be conducted using variables identified for measuring acceptance of blockchain in elections. Third, the countries analyzed (France and Russia) are located in Europe; deeper analysis of other regions could shed light on some potential differences. The authors see the potential for research in several areas. Blockchain technology offers huge potential for research focusing on peace engineering. Future directions include testing user acceptance of the system, cross-cultural comparisons, and implementing blockchain solutions in different industries with a focus on peace engineering. Blockchain-based technology should be considered an important topic, especially in interdisciplinary research fields.

CRediT authorship contribution statement

Patricia Baudier: Writing - review & editing, Supervision, Visualization, Project administration, Conceptualization, Methodology. **Galina Kondrateva:** Writing - review & editing, Methodology, Conceptualization, Formal analysis, Data curation. **Chantal Ammi:** Writing - review & editing, Methodology, Conceptualization. **Eric Seulliet:** Resources.

Acknowledgements

Authors would like to warmly thank the reviewers and the chief and guest editors of the journal for their relevant comments that drastically improved the article and all the interviewees from following companies or organisations GOLOS, TerraDoxa, Ftopia and Antena Forum. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declarations of interest

None.

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