Maintaining Voting Integrity using Blockchain

Steve A. Adeshina [1*] & Adegboyega Ojo [2*]

[1]Department of Computer Science, Nile University of Nigeria
email : steve.adeshina@nileuniiversity.edu.ng
[2]Insight Centre for Data Analytics, National University of Ireland, Galway. Republic of Ireland.
email : adegboyega.ojo@nuigalway.ie

◆

Abstract—The potentials of using blockchains and distributed ledgers to support voting processes have attracted significant attention in the electronic voting community. Most of these recent ideas are centered on blockchain-based e-voting protocols. Others focus on how blockchain can be exploited to simultaneously deliver auditability and anonymity of voters in the voting process. A common feature of these research efforts is the use of blockchain within e-voting contexts. We elaborate in this work the integrity requirements that must be supported by blockchain in online voting as well as offline voting prevalent in developing countries. The framework conditions for blockchain-based voting are also discussed.

Index Terms—blockchain, e-voting and blockchain, voting integrity, voting in developing countries

1 INTRODUCTION

Voting systems are important aspects of government information infrastructures in democratic societies [1]. Electronic Voting (e-voting) has the potentials to speed up, simplify, reduce the cost of elections and increase voters' turnout [2]. There are different models of e-voting including voting over the internet or some dedicated secure networks, using electronic voting machines at designated polling stations or using mobile phones and other specialised equipment to vote in an unsupervised manner. A number of countries including those in the developing world and particularly in Africa including Nigeria, Ghana and Kenya have adopted technologies to varying degrees in their electoral management and processes. The aspects of electoral processes currently supported include voters' registration, voters' identification, results transmission and tallying [3]. Interestingly, the adoption of e-voting in the developing world is often in highly politicized contexts, especially when used in general elections for executive offices (e.g. presidential elections) [4]. In fact, technology in these environments becomes the locus of attention in post-electoral disputes and its role in enabling or obstructing credible, free and fair elections come under scrutiny. Despite these shortcomings, e-voting lowers the cost of election participation and provides the most secure means for absentee voting [5]. In addressing the trust issues regarding technology use in e-voting, blockchain technology is receiving significant attention among electoral management authorities, politicians and other stakeholders. This interest is fuelled by the claims that e-voting is one of the key areas in the public sector that can be disrupted by blockchain technology [6], [7]. Blockchain-based e-voting potentially addresses the problem of voter access and fraud [7]. This has led to significant interest by policymakers and electoral management bodies all over the world on the transformational potentials of blockchains as an e-voting information infrastructure [2]. Blockchain technology has already been deployed within corporate organisational settings and community, city, sub-national levels, specifically for student government elections; non-profit organisations, and union voting, as well as subnational political-party events [7]. Albeit, these application scenarios have been largely consultative and non-binding. In Sierra Leone's election in March 2018, Blockchain was used for the partial tally of election results [7]. This paper examines the current landscape of blockchain-based e-voting, highlights the integrity requirements of the voting process such as those related to individual voters verifiability and ballot box integrity; and proposes a framework for blockchain-enabled solutions to protecting voting integrity in elections.

2 BLOCKCHAINS AND E-VOTING

There are at least two emerging streams of blockchain application in e-voting. The first stream involves the use of blockchain for e-voting (or blockchain-based e-voting – BEV). The other stream employs blockchain to non-intrusively support e-voting or voting processes as third party. This role is synonymous with those of third-party observers in elections. Advocates of Blockchain-enabled e-voting (BEV) seek to harness the decentralised blockchain protocols for voting without the control of a central authority such as the electoral management body. BEV attempts to eliminate the tampering with votes through cryptographically secure voting records. This enables votes to be recorded accurately, permanently, securely and transparently. Blockchain-based e-voting also protects the anonymity of voters while enabling public auditing of votes. According to [8], the followings characterise BEV and blockchain-based e-voting protocol:

1) Public Verifiability - members of the public involved in the election who can see the voting process recorded on blockchain can also verify the whole election's procedure and its outcome.

2) Individual Verifiability - voters are able to verify individual voting procedure, for instance, whether voter's ballot has been cast and recorded successfully, counted and tallied.

3) Auditability - the entire voting procedure recorded on the blockchain is auditable after the election

4) Anonymity - only voters themselves know the information of about votes, and all ballots in the ballot box are delinked from with their voters.

5) Transparency - the transparency of blockchain affords the entire voting procedure to be open to the public resulting in more fairness and validity of votes.

BEV guarantees the integrity of the voting process by its cryptographic algorithms and the consensus mechanisms of blockchain. It protects the voting process against external threats and attacks. In this scheme, voters are issued a "wallet" containing user credentials. Each voter gets a single "coin" representing one opportunity to vote [7]. Casting a vote involves transferring the voter's coin to a candidate's wallet. Voter's coin can only be used once but with the possibility of changing their vote before some pre-determined deadline. The design details of a BEV model are described in [14]. Similar blockchain-based voting ideas for integrating the management procedures of the phases and events of an election are described in [10]. These events include the set-up of the system, distribution of credentials, voting, collection of ballot papers, counting of preferences, and publication of results. Lastly, authors of [11] proposed a decentralized, anonymous and transparent voting system through an Ethereum blockchain-based solution. Transparency of voting is obtained by putting all messages on the Ethereum blockchain and the privacy of each voter by an efficient and effective ring signature mechanism. The system also affords self-tallying without the need of a trusted third party [11]. Highlights of these works are provided in Table 1 below.

TABLE 1: Example Blockchain-Base Evoting Solution

Blockchain application	Stage of Voting	Source
Wallet with a coin assigned to a registered voter.	Balloting	[7], [9]
Use of Smart contracts for large-scale voting.	Balloting in large elections	[12]
Cryto-voting	Balloting	[10]
Etherium-based voting transparency and privacy preservation.	Privacy of votes & tallying of ballots	[11]
Protocol for blockchain-based voting	Preparation, Balloting & Counting	[13]
Ensuring verifiability, anonymity & auditability	Balloting, Counting	[8]
Maintaining election results	Counting	[14], [15]

3 INTEGRITY ISSUES IN THE VOTING PROCESS

3.1 Electoral Integrity

Integrity is a key issue in the voting process and it does not matter whether such elections are purely manual or e-voting based. This work looks at the Integrity issues in the voting process within the Sub-Sahara African context. Whereas in many developed countries, trust appears to exist within the system, as a result of basic provisions by the government such as Identification systems, the situation is different in developing countries. In developing countries,

systems to support civic identification is often not available. In rare cases where these systems are available, updating the records of births/deaths and young person's attaining the voting age becomes an issue to contend with. Consequently, the requirement for the introduction of technology in the voting process to ensure integrity becomes extremely important.

Integrity depends on public confidence in electoral and political processes. It is not enough to reform institutions and introduce technology; citizens need to be convinced that changes are real and deserve their confidence. To ensure that elections have integrity, other factors outside of the electoral institutions themselves need to be taken into account and strengthened. Election officials, judges, and courts must have the independence that is respected by politicians

There is an ongoing debate over a single, universal definition of electoral integrity, but it can generally be defined as "any election that is based on the democratic principles of universal suffrage and political equality as reflected in international standards and agreements, and is professional, impartial, and transparent in its preparation and administration throughout the electoral cycle." (Kofi Annan Foundation, 2012) [1]

"The true measure of an election is whether it engenders broad public confidence in the process and trust in the outcome. An election run honestly and transparently, respecting basic rights, with the effective and neutral support of State institutions and the responsible conduct of participants (leaders, candidates and voters) is most likely to achieve an acceptable and peaceful outcome". [3]

Electoral integrity cannot be taken for granted. Mechanisms for promoting and maintaining integrity in every aspect of the electoral process are often established within the official bodies that administer or support the administration of elections. These mechanisms make it possible to monitor actions of the electoral administration; ensure oversight of the electoral process by other government sectors or agencies, civil society, and the media; and provide for enforcement of electoral rules and regulations through administrative or legal means.

Integrity is sometimes seen as a concern mainly for countries in transition to democracy, but electoral developments even in established democracies have shown that issues of integrity are equally important there. Examples include debates around voter registration practices in the United States during the 2000-2008 national elections [4] and mail-in vote fraud in Great Britain in 2005. [5]. The alleged Russian intervention in the last US elections and the ongoing impeachment proceedings against the siting US President are all indications to the effect that the issue of Integrity in elections is a global issue with varying dimensions.

3.2 Guiding principles for Electoral Integrity

Some of the guiding principles that can help bring about an election with integrity are:

- **Respect for principles of electoral democracy;** Under the principles of electoral democracy, all citizens have equal rights to: participate as voters and candidates; all citizens must have equal voting power; the secrecy of the vote must be assured; voters must have meaningful

access to electoral and campaign information; election administration must be conducted in a fair and non-partisan manner; elections must be held regularly; the results of elections must be decided by the freely cast votes of the citizenry.

- **Ethical conduct;** Integrity in elections depends on ethical conduct by electoral administrators, election officers, candidates, parties and all participants in the electoral process. A code of conduct for every stakeholder is of utmost importance,
- **Professionalism and Accuracy;** Integrity problems are often assumed to result from dishonest or fraudulent practices, but they can also be the result of human error or honest mistakes.
- **Institutional safeguards;** Institutional safeguards based on checks-and-balances are sometimes used to protect the integrity of elections. These involve dividing the authority to conduct various electoral operations among different bodies, providing a counterbalance to the electoral administration.
- **Oversight and Enforcement;** (Legal and institutional frameworks provide for oversight and enforcement of election laws to make administrators and participants accountable).
- **Transparency and Accountability.** Countries also adopt rules governing transparency to protect electoral integrity. With the right legislation, electoral administrators and election officers can be held accountable for decisions they make when administering elections; legislators for the content of the laws they pass and the level of funding allocated for elections; and candidates and political parties for their conduct and that of their supporters during the campaign. Regular consultations between policy-making bodies, the electoral management body and election participants can help build transparent electoral administration and greater confidence by the participants.

3.3 Integrity Issues in the Voting Process

The following have been identified as important integrity issues in the voting process.

- **System of governance** - In countries struggling with governance and suffering from weak rule of law, maintaining election integrity is much more difficult. The election management body and the political system have to demonstrate their institutional and administrative capacity and credibility.
- **Political culture** - In countries with deep social and political divisions, it may be difficult to agree on a national standard for integrity. Ensuring election integrity is much easier when there is a national or general consensus on the rules of the game and the value of integrity. Lack of funding and dependence on foreign aid - Countries with the shortfall in funding may depend on foreign aid. Suspicions about the motivation of donors may lead to questions about the integrity of elections.
- **Security** - Security issues can undermine election integrity. Voters, polling officials, and others may be subject to threats by those seeking to alter the outcome of the voting.
- **Lack of Trust** - The degree of trust may determine what additional measures to be taken to protect the integrity of elections.
- **New Technology** - New technology adoption can enhance integrity. Biometric voter register as used in several African countries have helped reduce multiple and underage voting – this was useful in Nigeria, Kenya and Sierra Leone. Some times new technology can create integrity issues as in Kenya where an election had to be annulled as a result of stakeholder mistrust in the system. Technology is most effective when suited to the local context. Dependence on foreign suppliers and licensed software usually leads to sustainability issues.

4 ADDRESSING VOTING INTEGRITY REQUIREMENT USING BLOCKCHAIN

While BEV has been proposed to address specific challenges in voting, the above electoral and voting integrity issues, present a robust set of requirements for an e-voting solution including blockchain-based voting solutions. We highlight in Table 2, how the aspects of the different integrity requirements can be supported by blockchain-based (e-voting) solutions. In some cases, these integrity requirements constrain how blockchain-based voting solutions must be implemented.

TABLE 2: Electoral/Voting integrity Requirements for Blockchain

Integrity dimension	Blockchain -support required
Respect for electoral democracy	Ensure equal voting opportunity and protect the secrecy of votes.
Ethical conduct	Provide smart contracts to enforce the code of conduct for all involved parties.
Professionalism and accuracy	Detect errors arising from human mistakes and possible fraudulent behaviours in validating voters and tallying of votes.
Institutional safeguards	Architecture must preserve the roles and authorities of relevant electoral institutions and entities but enforce correct behaviour through smart contracts
Transparency and accountability	The use of blockchain will not prevent electoral authorities and entities from being accountable. Rather, it will reinforce the accountability of relevant electoral actors within the legal and legislative environment.
Governance	Positioned as a critical socio-technical infrastructure for electoral authorities and management bodies to deliver credible elections.
Consensus on integrity	Must provide a mechanism for realising a concrete model of electoral and voting integrity that can be shared by all electoral actors.
Dependence on foreign aid	Must prevent any possibility of third-party intervention in the electoral process. All activities on the blockchain must also be transparent and auditable
Security	All electoral and voting events and records recorded on the blockchain infrastructure are secure

A number of the requirements in Table 2 above are socio-technical in nature and go beyond some of the reported

BEV initiatives reported in Section 2. In addition to BEV solutions addressing the integrity requirements, blockchain-based solutions, in general, must be able to support three voting and electoral scenarios. The first scenario consists of blockchains being directly implemented as an e-voting solution. The second scenario comprises of blockchains being deployed as an integrity layer around an extant e-voting system. The third scenario is related to blockchain supporting both online and offline voting processes that are typical of developing country's electoral environments. These three models of blockchain-enabled voting are given in Figure 1.
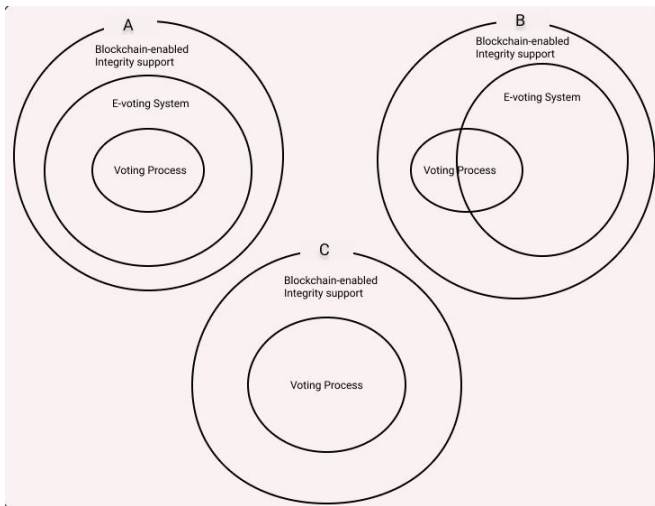

Fig. 1: Models of Blockchain-enabled voting.

The first scenario is the most common scenario that has been widely reported and piloted in literature. The second scenario involved making the blockchain a strategic "redundant" information store for important information being maintained within the e-voting system. In the third scenario (involving offline voting), processes to digitise and store critical information produced in the offline voting activities on the blockchain are designed. For instance, hash values of tally vote results, information about authenticated voters, digitized (scanned) results compilation sheet could be stored on the blockchain. As far as we know (except the very limited case of [7]), this third scenario which has significant potentials to ensure electoral and voting integrity in developing country contexts is yet to be really explored.

5 SOME FRAMEWORK CONDITIONS

First, the use of BEV must fit into the existing legal framework. Otherwise, the adoption of BEV will require an amendment to the legislative framework to accommodate the reallocation of authority and responsibilities associated with the use of the blockchain protocol. Related to this one of the requirements in Table 2 (Transparency and Accountability requirement). Secondly, the implementing authority must be ready to engage third-party to assess or audit and declare the fitness of the blockchain voting infrastructure. For example, in the BEV solution adopted by Moscow City Government, PWC was commissioned to undertake an audit of the system to ensure guarantee non-interference

through internal staff and external attack [7]. This is critical in building trust in the blockchain systems themselves. Thirdly, Like any other technology-enabled electoral technologies, blockchain-based solutions must be "simple, accurate, verifiable, secure, accountable and transparent" [4]. In addition, procurement, deployment, and testing of the blockchain solution must be completed several months before actual use in any election [4]. Fourthly, Electoral management bodies must have the requisite capacity to efficiently support the blockchain solution and providing adequate contingencies for unforeseen challenges that may arise [3]. Lastly, keeping ongoing communication with stakeholders in periods leading to the use of blockchains for election to convince stakeholders of the potential benefits and obtain the buy-in from political parties themselves is critical. In addition, the model of blockchain implementation must be tailored to the realities of the local environment.

6 CONCLUSIONS

Our goal in this paper is to articulate important integrity requirements for blockchain-based solutions and go beyond the current focus on BEV which does not consider other possible models of use of blockchains in elections and voting process. We do not claim that blockchains will deliver all integrity requirements described in Section 2, rather we have identified aspects of the integrity requirements we consider amenable to blockchain support. Our future work will examine cases of the novel blockchain use to maintain electoral and voting integrity in developing country contexts.

REFERENCES

[1] Francesca Caiazzo, "A Block-Chain Implemented Voting System - The benefits and risks of Block-chain Voting," 2016.
[2] P. Boucher, "What if blockchain technology revolutionised voting?," European Parliament Research Service, Brussels, Belgium, pp. 1–2, 2016.
[3] S. A. Adeshina and A. Ojo, "Factors for e-voting adoption - analysis of general elections in Nigeria," Gov. Inf. Q., no. November 2015, pp. 0–1, 2017.
[4] W. W. Chebukati, "Electoral Trust and Integrity: Is technology and enabler or barrier," 2018.
[5] J. Willemson, "Bits or paper: Which should get to carry your vote?," J. Inf. Secur. Appl., vol. 38, pp. 124–131, 2018.
[6] S. By and I. Systems, "TOWARDS THE DEVELOPMENT OF A COBIT 5-DRIVEN IT Alexander Ekow Asmah," no. August, 2019.
[7] N. Kshetri and J. Voas, "Blockchain-Enabled E-Voting," IEEE Softw., vol. 35, no. 4, pp. 95–99, 2018.
[8] Y. Liu and Q. Wang, "An E-voting Protocol Based on Blockchain," Pdfs.Semanticscholar.Org, 2017.
[9] U. Can Çabuk, E. Adıguzel, and E. Karaarslan, "A Survey on Feasibility and Suitability of Blockchain Techniques for the E-Voting Systems," Int. J. Adv. Res. Comput. Commun. Eng., vol. 7, no. 3, pp. 124–134, 2018.
[10] F. Fusco, M. I. Lunesu, F. E. Pani, and A. Pinna, "Crypto-voting, a Blockchain based e-Voting System."
[11] W. Lai, Y. Hsieh, C.-W. Hsueh, and J.-L. W. Wu, "DATE: A Decentralized , Anonymous , and Transparent E-voting System," no. HotICN, pp. 24–29, 2018.
[12] B. Wang, J. Sun, Y. He, D. Pang, and N. Lu, "Large-scale Election Based on Blockchain," Procedia Comput. Sci., vol. 129, pp. 234–237, 2018.
[13] F. S. Hardwick, A. Gioulis, R. N. Akram, and K. Markantonakis, "E-Voting with Blockchain: An E-Voting Protocol with Decentralisation and Voter Privacy," 2018.

[14] R. Hanifatunnisa and B. Rahardjo, "Blockchain based e-voting recording system design," Proceeding 2017 11th Int. Conf. Telecommun. Syst. Serv. Appl. TSSA 2017, vol. 2018-Janua, pp. 1–6, 2018.

[15] G. Van De Water, "BLOCKCHAIN BALLOT Electoral Enhancement or Danger to Democracy?," no. December, 2017.