Full Length Research Paper

Development of an Integrated Voting System and Method for Accommodating E-Ballots and Biometrics in Nigeria

*[1]Braimoh, Mikhelovba Ezekiel, [2]Al-Hasan, Fatimetu Olohigbe, and [3]Olubodun Ford Kolawole

[1]Department of School of Humanities and Social Sciences, School of General Studies, Auchi Polytechnic, Auchi, Edo State, Nigeria.
[2]Department of Public Administration, School of Bussiness Studies, Auchi Polytechnic, Auchi, Edo State, Nigeria.
[3]Department of Computer Science, School of ICT, Auchi Polytechnic, Auchi, Edo State, Nigeria.
Corresponding Author E-mail: zeekbraim@gmail.com

ABSTRACT: Threats of coercion, intimidation, or physical harm have an impact on Nigeria's voting process. Delaying, interrupting, or postponing a vote is one example of how violence can be used to exert control over a democratic process. In Nigeria, winners of competitive elections or referendums are desperate to win at any cost. In an election, two primary elements, namely INEC Ad-hoc workers, usually cause issues for the voting public. First, there is usually a lot of discussion concerning the voter's eligibility. This is because the individuals' ages and anthropometric measurements differ. Second, during election season, voters are routinely compelled to stand in long lines, exhausting them and rendering them unable to vote. Aspirants and their campaign staff also use deception to persuade voters to vote for them. When these variables are combined, any local, state, or national election is judged untrustworthy and unfair.

As a result, a system with characteristics to reduce existing system inefficiencies is required. This study expanded on a prior e-voting system by employing an integrated voting mechanism. It was created and tested at Nigeria's Auchi Polytechnic. The E-voting system used in this study combines Card Emulation and Reader-Writer modes. Although fingerprints can perform the same function as card readers, their individuality is preferable. It demonstrated that it may assist in the establishment of a voting system that would alleviate the problem of lineups during Nigerian elections. The study's findings indicate that the created e-voting technology will foster high voter turnout and the credibility of the political process.

Keywords: E-voting system, queuing, elections, integrated voting system, Nigeria

INTRODUCTION

Elections are critical in any democratic government, and the legitimacy of the voting process is sacred. The election is a recurring procedure that occurs at predetermined intervals. There are also different sorts of elections, distinct scopes of elections, and the requirement for several elections to be sponsored. Democracy, according to the rule of law, thus fosters human rights so that citizens can act and express themselves freely (Ayo, Daramola, and Azeta, 2011). Voting in elections is an essential component of democracy, and the presence of voters is required for democracy to function.

In addition to empowering voters to use this democratic right, the actions and processes that support the stance must be trustworthy, impenetrable, and free of bias. This allows residents to choose their representatives and freely express their opinions on problems. It strengthens citizens'

confidence and trust in a government or agency as it functions successfully and provides for an orderly handover of power.

Nigerian society is becoming more web-oriented and interactive, and people are beginning to set demanding requirements for government service delivery using new electronic delivery systems, taking advantage of the high degree of flexibility in services offered by the private sector, particularly the Internet (Ayo et al., 2011).

Transparency is an important issue for elections and the nature of an electoral system: ordinary voters should be able to recognize and see the technique of casting and counting ballots, even if they have little knowledge and trust. Throughout history, various polling systems have evolved, ranging from simple handwritten paper ballots to internet voting schemes that simply allow users to check in and vote from the comfort of their own homes using their personal computers (Hasan et al., 2014).

The electoral system is critical to the global survival of democracy. The Independent National Electoral Commission (INEC) of Nigeria, a government agency charged with the conduct and supervision of elections, has begun modernizing its information technology infrastructure by migrating from an outdated analogue voting system heavily reliant on inaccurate paper records and polling cards to the newer Electronic Voting System (EVS) (Adeshina, 2007).

The Electronic Voter Registry (EVR) is at the heart of EVS, capturing the names of all qualifying voters to eliminate overlap and hence minimize discrepancies in the voting process (Adeshina, 2007; Ayo et al., 2011). As a result, the EVR is utilized in Nigeria to ensure free and equitable elections. As part of the modernization process, INEC intends to inventory and spatially locate the agency's 120,000 polling locations dispersed across the country (Adeshina, 2007). Current events in Nigeria, where terrible election management has left countless individuals devastated, are causing tremendous concern among foreign leaders. As a result, attempts are being made to implement a voting system that is visible, convenient, and dependable. This study is one of several efforts aimed at ensuring a transparent electioneering process.

Literature review

Elections have become the norm for modern parliamentary governments, which stretch back to the 17th century (Ayo et al., 2011). An election is a formal decision-making method in which a candidate is chosen by a community or society to fill a political position. All political agencies, such as the legislature, as well as private and corporate organizations, such as the appointment of a corporate board of directors, technical club membership, and even philanthropic organizations, conduct elections (Ayo et al., 2011; Hasan et al., 2014).

There are many styles or divisions of elections conducted in most representative political structures related to the numerous levels of public government or regional authority. Common types of election categories are given thus (Ayo et al., 2011):

Presidential Elections
Parliamentary Elections
Governorship Elections
Local Government Elections

Considering our defined domain, that is, there are also different forms of elections within the polytechnic political realm that are carried out based on specific parameters that help to delineate the polytechnic staff/students into groups such as Academic or Non-Academic, Senior Staff, Cooperative Union, Students Unions to name a few. Nigeria's diverse ethnic groups also have numerous ways of choosing their rulers (e.g., Obas, Emirs, Igwes, etc.) and their traditional kingdoms. There are two (2) main categories in which voting systems can be classified: traditional or paper voting systems and electronic voting systems (Hasan et al., 2014). Whatever voting system is used, it must be able to withstand a range of fraudulent activities. Voters and candidates should be able to accept an election result if it is sufficiently transparent and understandable. The most difficult aspect of traditional voting procedures is the tallying form. The manual approach is imprecise, which is a major flaw in this system that has sparked a lot of controversy (Hasan et al., 2014; S. Heiberg, 2012).

Even in recent presidential elections, complaints regarding the ballot counting procedure occurred after the US presidential elections in 2000. (Hasan et al., 2014). Ballots might be shifted during tally counting, and ballot markings can be difficult to detect and understand (Ayo et al., 2011; Hasan et al., 2014). Because the voting exercise has been digitalized to keep count of the tallies using NFC ID systems to prevent multiple voting, voter misidentification, and the confusion of discriminating between poorly signed ballots, we have been able to sufficiently simplify the repetitive task of tallying and mitigate voter fraud, long queues, save time, and, of course, improve efficiency.

NFC technology improves usability by allowing users to connect their ID card to their computer in a simple and basic manner (Ok, Coskun, and Aydin, 2010). Only NFC cards, being the critical entry mechanism of a voting system, might make it vulnerable to attacks (Ok, Coskun, and Aydin, 2010).

Having only an ID card, on the other hand, allows a voter to cast several ballots using different voter ID cards. Still, the study was able to modify the NFC system to relate and respond to identities already captured in a prepared database by allowing voting actions to take place once for each voter's bio-data but rejecting a second try/attempt and refusing to identify any smart card or tag containing voter's information that was not found to have been preserved in the database for accurate biometric testing.

Biometrics in voting processes have been praised because fingerprints are unique to each individual. Still, the difficulties of having multiple fingers that the finger sensor fails to recognize during national primary elections, as was seen in the 2015 elections when President Goodluck Ebele Jonathan and his wife, Dame Patience Jonathan, were unable to vote due to a fingerprint sensor failure, makes the use of smart cards and tags a viable option for this study.

The new technology connects voters' smartcards or tags to a predefined database, where the voters' NFC ID card details match their bio-data that was previously encoded in an encrypted chip. After the authentication and matching of the two results, the voter is allowed to vote. By automating and using a synchronized system of identity schemes, the method eliminates the risk of any unauthorized entries.

In a nutshell, biodata of voters are collected in the voters' registration system before voting in the practical use of smart cards or tags with encrypted chips; these smartcards or tags are linked to an existing database to which individual voters' data or basic facts are allocated. No two smartcards or tags can be used interchangeably. Because the chips record every data for specific usage, the algorithm is created or coded to allow voting with one card just once in every election exercise or voting procedure. Because the data has not been assigned to a specific card or tag, it will not be eligible to vote. In the long term, it eliminates the indecencies of fraud suggested by OK, Coskun and Aydin (2010) in their study.

Types and functionality of the NFC

NFC enabled devices to communicate with each other using electromagnetic waves; this NFC technology supports three modes of communication; they are:

a.   Peer to peer mode, e.g. sharing information on Xenda, Bluetooth or Xshare.
b.   Reader-Writer mode- With this, devices communicate with each other using electromagnetic induction, in which active properties are transmitted through radioactive waves. The passive device uses signal response back to signal using the load modulation techniques.
c.   The card emulation mode uses encrypted data in smart cards, phones, and tags to reveal data in its storage chips

when swiped over a sensitive electronic device with which it is programmed to interact.
This study's locally manufactured E-voting system combines Card Emulation and Reader-Writer modes. Although fingerprints may perform the same functions as card readers, their uniqueness makes them preferable to card readers, which is fine. Given the population and vast

traffic of voting activities in some elections, smart cards and tags are more efficient in reaching out to significant people over a large area or spread. Even though smart cards are vulnerable to fraud and manipulation, they are thought to be faster in terms of allowing accreditation and voting to take place virtually simultaneously. Voters' information is processed and recorded in a pre-existing database or a dedicated database via email or any other platform while utilizing the smartcard. In this situation, the card reader is thought to be more efficient because it can recoup voters' bio-data and recognize any card-carrying same when swiped across the surface of any sensitive gadget designed to communicate with it for such purposes.

Challenges with Smart Cards/Tags

1.   Easily manipulated
2.   Handlers or electoral umpires (custodians) may hoard, withhold or hide cards from helpless voters due to corrupt influences who want to rig elections in favour of any powerful politician.
3.   The process is only very effective for a literate population.
4.   Identity theft is a possibility.

The advantage of smart cards or tags over the fingerprint option is that at times when the traffic of humans or voting exercise is high, the fingerprint option may develop glitches when the sensor finds it difficult to recognize some fingers; this was very common in 2015 general elections in Nigeria which then necessitated the use of incidence forms albeit the abusive use of the incidence form with careless abandon. Similarly, facial recognition smart devices could enable voters to vote even from their homes using application software for such purposes. Still, again, this method is considered most efficient for a widely literate population or society.

Other problems confronting the adoption of E-voting in Nigeria

1.   The selfish ambition of politicians who often seek ways to manipulate the outcome of elections.
2.   The reluctance on the part of the government to embrace the e-voting option
3.   The poor condition of energy supply in most remote places in Nigeria, albeit the slow pace of development and patronage of renewable or gridless energy sources for powering E-voting devices.
4.   Poor internet accessibility in Nigeria has no widespread presence of internet facilities in most rural and semi-urban settlements in Nigeria.

The impotence of the E-Voting System/Process

1.   Decongestion of polling units

2.	Innovative technology is potent for eliminating the fraud associated with conventional voting procedures

3.	The use of e-voting facilitates a process that requires little or no strict supervision.

4.	The use of e-voting will eliminate the tension associated with the election and reduce the incidence of electoral violence in Nigeria.

5.	E-voting combined with sufficient voters' education can be conducive to the election in a mixed society of both literate and illiterate populations.

6.	E-voting saves time and resources.

Electoral Violence in Nigeria

In many general elections in Nigeria, local and international observers seem to have been unanimous in their reports that elections in Nigeria generally fall below internationally accepted standards. For instance, the 1999 election that brought Chief Olusegun Obasanjo to power was said to have been marred by widespread fraud Priye (2010). As Harry and Kalagbor (2021) put it, the democratic experience since 1999 has been fraught with so many undemocratic tendencies and practices, rigging, violence, voters' apathy, vote-buying, etc.

Nigeria's electoral system and processes have been characterized by so much fraud and other irregularities, thereby denying a vast majority the right to choose who governs them genuinely. (Harry and Okagbor, 2021) These study has helped influence our urge to seek to provide affordable solutions to the problem of elections and all other cries generally associated with voting in Nigeria.

Theoretical framework

Technology Acceptance Model (TAM) is one of the theories used to explain internet or electronic device usage and its acceptance in society. The theory posited that the new device user perceives its usefulness and the ease to use it can be used to explain their acceptance of the device (Chuttur, 2009; Dwivedi et al., 2017). Thus, the extent to which the user sees the importance of technology and the time to which the user feels they can easily use it is critical to their willingness to use the technological device.

Halewood and Surya (2012) outlined how technology can be helpful to electorates in enhancing the electoral process. One of the ways to cast and secure votes electronically and efficiently, most especially by the electorates is through e-voting device or technology. The e-voting system or device uses several ICT applications and tools that can support the process of casting votes during election at every stage, from voter's identification, biometrics, casting votes and counting the votes in a fast and reliable manner. The e-voting device has the following advantages to the electoral system:

• 	Enhance quick access to voter's verification exercise

• 	Improved access to an effective and efficient voting system using the device.

• 	It allows a more efficient and transparent counting of votes

• 	Make the process more efficient and transparent

• 	Reduce the incidence of electoral malpractice.

• 	They also help teach the culture of credibility and fairness into the electoral system.

METHODOLOGY

The research design is the methodology adopted for this study. This methodological approach enables the researcher to elicit responses from the respondents through the administration of questionnaires. The study population comprises 116 staff from the three departments (Humanity and Social Science 70, Basic Science 23, Languages 23) that make up the School of General Studies. A simple random technique was used to sample 79 respondents from the targeted population. The researchers' structured research instrument is a five-point Likert scale composed of twelve items used for data collection. The instrument has response options of Strongly Agreed (SA) 5points, Agree (A) 4points, Undecided (UN) 3 points, Disagreed (D) 2points, and Strongly Disagreed (SD) 1point. The simple percentage was used to analyze the data derived from the survey using the Statistical Package for Social Sciences (SPSS) version 22.

RESULTS

According to the data in (Table 1), the mean response/result of the respondents in items 1, 2, 3, and 4 of research question one is 4.74, 4.09, 4.70, and 4.71, with a grand mean of 4.57. As a result, there is widespread acceptance of the influence of the created e-voting system, in which the legitimacy of votes and voters is verified using technologies such as NFC and biometric registration. The respondents agreed that the designed e-voting system is long-lasting and practical, secure, and offers effective NFC and biometric registration; it will eliminate election malpractices and aid in the validity of votes cast, promoting the legitimacy of the voting process. According to the statistics in (Table 2), the mean responses/results of respondents in items 5, 6, 7, and 8 of the survey are 4.27, 4.30, 4.20, and 4.19, with a grand mean of 4.24. The study discovered that respondents agreed that the features of the developed e-voting system's voter identification biometric are enhanced to perform optimally, that the voter identification biometric developed from the e-voting system is better than the manual registration system in use, that the voter

Table 1: To develop a secured e-voting system where the authenticity of votes and voters are ensured using mechanisms such as NFC and biometric registration.

ITEM	Response					Mean	Remark
	SA	A	UN	D	SD		
The developed e-voting system is durable and effective	60 (75.9%)	19(24.1%)	-	-	-	4.76	Accepted
The developed e-voting system is secured and ensures practical NFC and biometric registration	13(16.5%)	62(78.5%)	4(5.0%)	-	-	4.09	Accepted
The developed e-voting system will erase malpractices during elections	55(69.6%)	24(30.4%)	-	-	-	4.70	Accepted
The developed e-voting system will aid the authenticity of votes cast and promote the legitimacy of the voting process.	63(79.7%)	9(11.4%)	7(8.9%)	-	-	4.71	Accepted
Grand mean						4.57	Accepted

Source: Field Survey, (2022)

Table 2: To improve voter identification since biometric features cannot be shared.

ITEM	Response					Mean	Remark
	SA	A	UN	D	SD		
The features of the voter's identification biometric of the developed e-voting system are enhanced to perform optimally	21(26.6%)	58(73.4%	-	-	-	4.27	Accepted
The voter's identification biometric developed from the e-voting system is better than the manual registration system.	24(30.4%)	55(69.6%)	-	-	-	4.30	Accepted
The voter's identification biometric capture the electorate's fingerprints properly and speedily	16(20.3%)	63(79.7%)	-	-	-	4.20	Accepted
The voter's identification biometric features of the developed e-voting system are practical and efficient.	19(24.1%)	56(70.9%)	4(5.0%)	-	-	4.19	Accepted
Grand mean						4.24	Accepted

Source: Field Survey, (2022)

Table 3: To ease the queuing problem during the voting period in elections.

ITEM	Response					Mean	Remark
	SA	A	UN	D	SD		
The developed e-voting system is fast and reliable	11(13.9%)	68(86.1%)	-	-	-	4.14	Accepted
It will help to erase the challenge of queuing during verification and voting in elections	9(11.4%)	67(84.8%)	3(3.8%)	-	-	4.08	Accepted
The e-voting machine developed will help to encourage a large turnout of electorates during elections	64(81.0%)	15(19.0%)	-	-	-	4.81	Accepted
It will give legitimacy to the electoral process	79(100.0%)	-	-	-	-	5.0	Accepted
Grand mean						4.51	Accepted

Source: Field Survey, (2022)

identification biometric captures the electorate fingerprints properly and quickly, and that the voter identification biometric features of the developed e-voting system. Because biometric traits cannot be shared, the investigation concludes that the created e-voting method has broad acceptance for improving voter identification. According to the data of the respondents in (Table 3), the mean responses/results of the respondents in item 1, 2, 3, and 4 of research question three are 4.14, 4.08, 4.81, and 5.0, with a grand mean of 4.51.

Thus, the analysis reveals that the created e-voting method is generally acceptable for easing the problem of queuing during the voting time on election days.

According to the findings of the study, respondents agreed that the developed e-voting system is fast and reliable, that it will help to eliminate the challenge of queuing during verification and voting in elections, that the designed e-voting machine will help to encourage large turnout of electorates during elections, and that it will provide legitimacy to the electoral process in Nigeria.

DISCUSSION

Elections are central features in every democracy. This is because of the moderating, and mitigating effects

elections have on the process of political recruitment and in ensuring stability in society. At all levels of governance, the nation's elections are characterized by violence. Violence mar as high as 70 percent of Nigerian elections resulting in deaths, destruction of properties, maiming, etc. Successive governments have made frantic efforts to institutionalize and consolidate democracy, embarking on various electoral reforms with little or no result concerning curbing electoral violence (Kalagbor and Harry, 2021).

Thus, in the quest to ascertain the developed e-voting system's authenticity, the study revealed that the developed e-voting system is durable and practical, ensures effective NFC and biometric registration, and will erase malpractices during elections, promote credibility and legitimacy to the voting process in Nigeria. The findings of this study confirm the yearning and desire of Malkawi, et al. (2009); they posited that e-voting usually embraces correctness, robustness against fraudulent election behaviours, coherence, consistency, security, and transparency of voting, which are all critical requirements for the integrity of an election process.

The voter's identification biometric capture the electorate's fingerprints speedily, adequately, effectively, and efficiently. Moreso, to determine if the developed e-voting device improves voter's identification and biometric, the study discovered that the voter's identification biometric of the developed e-voting system is enhanced to perform optimally and better that the manual registration system in use. The study position was affirmed by Okediran and Ganiyu (2015); they observed that the design of any voting system, whether electronic or manual, must satisfy several sometimes competing criteria, including a high degree of security and accuracy, eligibility and authentication, integrity, verifiability and suitability, reliability, flexibility, performance and scalability. These features listed are critically embedded in the developed integrated e-voting system.

For election to be free, fair and credible in the modern age, it must be e-voting that will entrust acceptability and legitimacy. It is generally considered that a critical component of electronic government is e-voting as a means of facilitating the participation of citizens in elections and public debates. Furthermore, to establish if the e-voting system will ease the problem of queuing during the voting period in Nigerian elections, the study revealed that the developed e-voting system is fast and reliable during verification exercises and voting in elections and, as such, will encourage large turnout of electorates during elections and give legitimacy to the electoral process. The study supports the observation of Kohno et al. (2003); they posited that any election system must be sufficiently robust to withstand a variety of fraudulent behaviors and must be sufficiently transparent and comprehensible that voters and candidates can accept the results of the election. Thus, for a society to be consensus-based or democratic, elections and voting remain fundamental and crucial.

Conclusion

Citizens must vote in order to participate in any democratic process. This study investigates the credibility of the integrated e-voting device system in Nigeria's quest for credible elections. However, the concept of free, fair, and reasonable approved elections in Nigeria remains a contentious issue. The validity and trustworthiness of elections in the past have been warped by ardent malpractices, manual registration, and voting patterns, which do not all imply the same thing to everyone. As the number of e-government apps develops, so does the popularity of e-voting. It is gaining popularity as a potential alternative to traditional election systems for generating accurate and trustworthy results. As a result, several countries are experimenting with various e-voting models and approaches to allow voting through various electronic channels. The introduction of e-voting will surely allow voters to cast their votes with credibility, facilitate quick vote casting, allow huge participation in elections by those qualified to vote, boost voter turnout, and widen access to the voting process for voters with disabilities.

ACKNOWLEDGEMENTS

REFERENCES

Adeshina, T. (2007). GIS Prevails Despite Unnavigable Terrain and Political Unrest Nigerian Voting System Modernized. Retrieved December 27, 2020, from https://www.esri.com/news/arcnews/summer07articles/nigerian-voting.html

Ayo, C. K., Daramola, J. O., and Azeta, A. A. (2011). Developing a Secure Integrated E-Voting System. In Handbook of Research on E-Services in the Public Sector (pp. 278–287). IGI Global. https://doi.org/10.4018/978-1-61520-789-3.ch022

Chuttur, M.Y. (2009). Overview of the Technology Acceptance Model: Origins, Development and Future Directions, USA, Indians University. Sprouts: Working Papers on Information System, Vol. 9.

Dwivedi, Y. K., Rana, N., Jeyaraj, A, and Clement, M.(2017). Re-examining the Unified Theory of Acceptance and Use of Technology (UTAUT): Towards a Revised Theoretical Model, *Information Systems Frontiers,* 21(3):1-16

Halewood, N. J. and Surya, P. (2012). Mobilizing the Agricultural chain, *information and communication for development*, 31 – 44.

Harry, D. M., and Kalagbor, S. B. (2021). Electoral violence and democratic consolidation in Nigeria: Issues and challenges, *Advances in Social Sciences Research Journal,* 8(7): 140-156

Hasan, S. M., Anis, A. M., Rahman, H., Alam, J. S., Nabil, S. I., and Rhaman, M. K. (2014). Development of electronic voting machine with the inclusion of Near Field Communication ID cards and biometric fingerprint identifier. In 2014 17th International Conference on Computer and Information Technology (ICCIT) (pp. 383–387). IEEE. https://doi.org/10.1109/ICCITechn.2014.7073090.

Kalagbor, S. B. and Harry, D. M. (2021). "Development Policy, Plan and Economic Diversification in Nigeria: Perspectives on Economic

Recovery and Growth Plan", *EJDEVELOP*, 1(3): 43-52.

Kohno, T., Stubblefield, A., Rubin, A. and Wallach, D. S. (2003). "Analysis of an electronic voting system" *Johns Hopkins University Information Security Institute Technical Report* TR-2003-19.

Malkawi, M., Khasawneh M., and Al-Jarrah O. (2009). 'Modeling and simulation of a robust e-voting system', *Communications of the IBIMA*, 8(1).

Ok, K., Coskun, V. and Aydin, M. N. (2010). Usability of Mobile Voting with NFC Technology. In Proceedings of IASTED international conference on software engineering (pp. 151–158). Canada.

Okediran, O. and Ganiyu, R. A. (2015). A Framework for Electronic Voting in Nigeria *International Journal of Computer Applications*, 129(3): 975-8887

Priye S.T (2010). Corrosive effect of corruption on Nigeria's Electorial system. http//www.gamji.com/article6000/new7987.htm