**DESIGN AND SIMULATION OF REAL-TIME SHORT MESSAGE SERVICE-BASED VOTING SYSTEM**

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***ABSTRACT***

*Voting is an important aspect of the democratic process in which the electorates select those that will represent them at all levels of government as well as in organizations using various technologies. The efficiency, reliability and security of the technologies involved in such a voting system become of paramount importance. In the bid to curb all the anomalies involved in the traditional voting systems, the design and simulation of a real-time Short Message Service-based voting system in Nigeria was developed. This was achieved by first carrying out a comprehensive review of the already existing e-voting systems to ascertain any limitations associated with them. Inefficiency in preventing electoral fraud and keeping the electorate informed of the real-time results of the ongoing election as well as the result immediately after the election is over were the major drawbacks identified with the existing systems. These were attributed to its architectural design and security algorithm making them unreliable. The inclusion of a real-time Short Message Service in the already existing architecture among others is therefore proposed as a solution to the identified drawbacks. The proposed system was implemented using Hypertext Preprocessor (PHP), Hypertext Markup Language (HTML), Structured Query Language (SQL), SMS enabler, Android studio and Apache Web server technologies. The result showed that the SMS features, security, as well as intelligence incorporated in this work, had zero impact on the success rate of the system. There was an increase in the latency of the existing system by 16.8%, though still has a tolerance of 30.5% to reach saturation point while preventing electoral fraud, since the maximum latency for successful vote casting is 60 seconds. This work confirmed that with this proposed e-voting system with a re-engineered architectural model, electoral fraud can be totally eradicated*.

**Keywords**: Database, HTML, PHP, SMS, SQL

**INTRODUCTION**

An election is key to the existence, stability and development of democracy in any country. Therefore, the electoral system of a government determines the political growth and democratic stability of that society [1]. In Nigeria, the agency charged with the conduct and supervision of elections is the Independent National Electoral Commission (INEC) which was empowered by the 1999 constitution to conduct a free and fair election. Five methods of voting have been used so far in Nigeria. These are Open Ballot System (OBS), Modified Open Ballot System (MOBS), Re-modified Open-secret Ballot System (REMOBS), Continuous Accreditation and Voting System (CAVS), Bimodal Voter Accreditation System (BVAS).

Open Ballot System also known as Option A4 is a voting method in which voters vote openly by queuing or otherwise to indicate the candidate of their choice [1]. This method was used for 1979, 1983 and the June 12, 1993, elections [2]. The Modified Open Ballot System is a modified version of the popular open ballot system. The distinction between the two is that the open ballot exposes to everyone at the polling booth the choice of a voter while the MOBS, though open allows voters to secretly make their choice. This method was embraced in the 1999, 2003 and 2007 general elections respectively [2]. Furthermore, the Re-modified Open-secret Ballot System (REMOBS) was implemented in the 2011 and 2015 general elections. Under this method, accreditation of voters commences at the same time throughout the country while voting takes place immediately after accreditation across the federation [3].

Continuous Accreditation and Voting System (CAVS) was introduced immediately after the 2015 general election by the INEC Commission. This procedure permits accreditation and voting to be done simultaneously. The accreditation process comprises verification and authentication of voters by the smart card reader (SCR), identifying voters through the register of voters and inking of the cuticle of a specific fingernail. After accreditation, the voter is issued a ballot paper to make his/her choice secretly inside the enclosed area provided by INEC and deposits the ballot paper inside the ballot box in the presence of everyone in the polling station. This method was adopted in all the elections conducted after the 2015 general election and was eventually used for the 2019 general election.

In the most recent times, INEC has introduced another technique into the e-voting system which is called the Bimodal Voter Accreditation System (BVAS). This procedure eliminates the use of a smart card reader for accreditation and manual searching of voter information from the voter register. In addition, it is used to upload the polling unit results to INEC result viewing portal (IReV) for all stakeholders to view the outcome of the election.

INEC’s modernization plan as regards the electoral process of the country prompted the implementation of the electronic voter register (EVR) which was used for registration of prospective voters in 2007. It involved the use of direct data capture machines (DDCMs) to capture the information of voters electronically with a view to eliminate most of the problems associated with previous elections and ensure free and fair elections in Nigeria, but it is now replaced with another device called INEC voter enrollment device with an online registration portal in 2021. Although the implementation of EVR eliminated duplication of names on the register which subsequently minimized discrepancies in the electoral process in Nigeria. However, research shows that it was marred by poor logistics and other irregularities.

Electronic voting also known as e-voting is a [voting](https://en.wikipedia.org/wiki/Voting) system that uses [electronic](https://en.wikipedia.org/wiki/Electronics) means to either aid or support the casting and counting of votes. Depending on the particular implementation, e-voting may use stand-alone electronic [voting machines](https://en.wikipedia.org/wiki/Voting_machines) (EVM) or computers connected to the Internet [3]. It may encompass a range of [Internet](https://en.wikipedia.org/wiki/Internet) services from basic transmission of tabulated results to full-function online voting through common connectable household devices [3]. The degree of [automation](https://en.wikipedia.org/wiki/Automation) may be limited to marking a paper ballot or maybe a comprehensive system of vote input, vote recording, data encryption and transmission to servers, consolidation and tabulation of election results. A worthy e-voting system must perform most of these tasks while complying with a set of standards established by regulatory bodies and must also be capable to deal successfully with strong requirements associated with [security](https://en.wikipedia.org/wiki/Computer_security), [accuracy](https://en.wikipedia.org/wiki/Accuracy), integrity, swiftness, [privacy](https://en.wikipedia.org/wiki/Privacy), [audibility](https://en.wikipedia.org/wiki/Electronic_discovery), [accessibility](https://en.wikipedia.org/wiki/Accessibility), [cost-effectiveness](https://en.wikipedia.org/wiki/Cost-effectiveness_analysis), [scalability](https://en.wikipedia.org/wiki/Scalability) and [ecological](https://en.wikipedia.org/wiki/Ecology) sustainability.

In addition, the voting system must ensure adequate protection of the voting clients and votes cast including other election materials which will curb the risks of program error, software attack or system hacking, risk of fake voting sites and eventual submission of electronically altered results as a result of computer viruses. Any electronic voting machine that will produce transparent and credible elections in Nigeria must have real-time transactional monitoring capability and transmission. Transmitting accreditation and result data immediately after the poll will reduce instances of electoral fraud most especially at collation centres [4].

In a study by [5], it was stated “that the use of mobile phones is a cost effective and secure voting medium through the use of short message service”. With the use of mobile phones at election it is glaring that the use of ballot papers, ballot boxes etc. will be eliminated and the number of manpower needed will drastically reduce thereby increasing cost efficiency. It is also secured as it has been stated by him in the sense that voters can now vote from their privacy without fear of being harassed.

Some of the benefits of SMS based voting system over traditional paper-based voting systems are access to democratic processes support, reduction in cost of electoral materials production, distribution and mobility, increase the likelihood of participation for mobile voting, tracks voting progress and collation of result in real time, access to more information regarding voting options, step by step processes help minimize the number of invalid votes, ease and speed, multi-language support and the flexible design allows up-to-the-minute ballot modifications.

According to [6], electronic voting has been a topic of interest for many years which is still not fully resolved. Online voting systems contain a security conﬂict such that it may be possible for authorities to conduct fraud or do manipulations which are diﬃcult to detect by other participants. In their research work, a double-layer security model was proposed and tested to prevent manipulations that may occur during the elections and with the election results. It was ensured that the election results can be counted after the participation of all stakeholders. As a result of the model, the privacy of a voter is secured, no central authority is needed, and the recorded votes are kept in a distributed structure. In this way, potential manipulations may be prevented during the elections. It was also tested that the system continues to work even if a node becomes inoperable.

[7] implemented a fingerprint-based voting system using RFID. Their proposed schemes are very suitable for real-time management. The fingerprint-based voting system is accurate, and it avoids fake votes. This voting system is more accurate and fairer because only eligible candidates can poll the vote. The fingerprint recognition techniques provide more privacy to the voting system. In a case, any unauthenticated individuals try to cast their votes the buzzer is capable of alerting the presiding officer as soon as possible. The voting scheme is considerably designed for 99% of users.

[8] research on E-voting system evaluation based on the Council of Europe recommendations said despite the claimed benefits of e-voting initiatives, wider adoption of e-voting mechanisms and implementation processes is slower than expected. Several technical, social, and cultural challenges hinder the generality and applicability of e-voting. Amongst them, the evaluation and harmonization of e-voting systems given different legal and statutory frameworks is still an important challenge to overcome. Yet, only a few works have addressed this topic in the field.

[8] research aims to contribute further understanding of the unexplored topic by applying a practical evaluation framework to Helios Voting which is one of the most widely used e-voting tools to date which framework, is strongly based on the technical and security requirements issued by the Council of Europe in 2017. it is a valuable source of information for election officials, researchers and voters to understand the strengths and weaknesses of Helios Voting and as a result, improve decision-making processes regarding the type and size of elections that can be securely handled by Helios Voting system. The ultimate goal of the research work is to conceptually and practically support the gradual, secure and protocolized expansion of e-voting.

The SMS Based Voting System uses two mobile phones of which one is the transmitter, and the other phone is the receiver [9]. The receiver mobile is interfaced with Microcontroller unit while the transmitter mobile is voter’s mobile. When the voter wants to vote, he will enter the correct voter identification number, password and then enter candidate’s identification number in the message to enroll his vote. The sent details to the receiving mobile phone will be matched with the details in the data base if it is the same then the vote will be counted for the selected candidate whose identification number came with the vote and is stored in a database where tallying takes place automatically [9].

[10] investigated the design and implementation of mobile voting system in student union government election at Lagos State University in which the student has to visit the polling booth before they can cast their vote because of the Direct Recording Electronic system of voting in use. To solve the problem of students covering the distance from their hostels, classrooms etc. to the polling booth and wasting quality study time in queues during student elections the technology of the Remote (e-voting) system comes into existence. Remote electronic voting systems make the casting and counting of votes more convenient and efficient, even making the electoral procedures simple and reducing the mistake of ballot examination [11].

The stressful and gory experiences associated with elections in Nigeria are a pointer to the inevitability of the electronic voting system in Nigeria. Hence, this paper aims at studying the required e-voting system in Nigeria; it is believed that the full implementation of the e-voting system in Nigeria will save the country from the awful experiences of the past as it promises free, fair, transparent, convenient and confidential elections as well as the speedy processing of results [12]. This research work will proffer solutions to some of the shortcomings of already existing systems by implementing complete electoral automation as well as incorporating short message service feedback.

**MATERIALS AND METHOD**

In order to realize a highly reliable real-time Short Message Service based voting system, this work adopts a process model called the waterfall reuse model of the System Development Life Cycle which is a combination of both waterfall and reuse model of the System Development Life Cycle.

**The Proposed System**

The proposed model of the real-time Short Message Service-based voting system is shown in Fig. 1. This model comprises two ends: the user end and the server end. The user end is a smart device such as a mobile phone that can communicate with the server end through a wireless means of communication.

**VOTER MODULE**

**VERIFICATION MODULE**

**VOTE COUNT / COLLECTION MODULE**

**SMS MODULE**

**VOTER MODULE**

**ADMIN LOGIN MODULE**

**VOTER REGISTRATIONMODULE**

**DATABASE STORAGE**

**Server end**

**User end**

Figure 1: Block Diagram of the Proposed Model of the Real Time Short Message Service Based Voting System**.**

Voter Login Module: This module is responsible for granting or denying the voter access to the application to cast ones vote. This is achieved by this module by accepting the voter’s login code and then verifies it to ascertain if the voter is a registered voter or not. If the voter is a registered voter, then the voter will be granted access to the voter module, else denied access.

Voter module: This is the interface used for voting, it aids capturing of the voter’s identity, phone number, the party voted for and the time of voting and then transmit the information to the vote count/collection module.

Verification Module: This serves as the receiver, it receives the information from the voter module and checks if the voter has voted before based on the on-going election. If yes, the vote will be invalid and discarded but if the voter has not voted previously, the voter’s available information will be transmitted to the vote count/collection module.

Vote Count/Collection Module: This module is responsible for counting and collation of votes cast with respect to the various parties, sending the voters’ information to the sms module for instant messaging. It is also responsible for retrieving the total result of votes cast at the end of every election and as well as forwarding it to the SMS module for instant messaging.

SMS Module: This is solely responsible for Sending Instant Messages (SMS) to the various voters.

Database Storage: This functions as a reservoir for holding all the required information of the voters as well as the information of the votes cast for each participating party.

Administration Login: This module allows the admin to login into the admin unit and this is achieved by accepting the admin’s login code and then verifies it to ascertain the authenticity of the admin. If the verification is successful, the admin will be granted access to the registration module and to view the progress of the elections at the moment.

Registration Module: This module as the name depicts, allows the admin to carry out the function of registration of eligible voters.

**Design Specifications**

Following the block diagram overview of the proposed model of the real time Short Message Service based voting systems shown in Fig. 1, our design will focus on the two layers: access/virtualization layer and logic instance with the server side. In this context, the grid control is the major component in the proposed system SaaS application. The logic instance and the background processes facilitate connection to the server. The model specifications are as follows:

Prototype deployment server system requirements are:

1. Memory requirements:

1 GB for the logic instance (grid control)

1. Disk space requirements:

– 1.5 GB of swap space

– 400 MB of disk space in the /tmp directory

– Between 1.5 GB and 3.5 GB for the system’s software

– 1.2 GB for the preconfigured database (optional)

– 2.4 GB for the flash recovery area (optional)

1. Operating system requirements

- Adequate temporary space

- 64-bit versus 32-bit issues

- Windows 8/Server 2007 and Linux Redhart

- OS patch level

- System packages

- System and kernel parameters

- Sufficient swapping

- Nonempty XAMP htdocs\_HOME

- MySQL database

**System Flowcharts**

In this section, we shall present the respective flowcharts of the proposed model of the real-time Short Message Service-based voting system.

Yes

Process and confirm eligibility and load election of the moment.

B

Process and initialize to login password

Selection of party/candidate by voters and process/check if the voters has already voted for that election

Display Error Message: Invalid! You are not a registered Voter.

Displays the election vote Interface to Vote

Database: check voters status (Biodata)

Is the Voter Registered?

No

B

Has the voter previously voted for this election?

Accepts the vote from voter

Processes and check if the voting has ended.

Has the voting ended?

Continue Voting/Counting

Processes the vote and add it up to the already counted vote.

Sends the vote count to the voter via SMS

Processes and send collated results of the election.

Yes

No

Yes

Displays: Voter already voted for the election.

No

Figure 2: Flowcharts of the Proposed Model of the Real Time Short Message Service Based Voting System

Figure 2 shows the flow chat design for the proposed model of the real time Short Message Service based voting system. In this model, to gain access to the application so as to vote, the user must provide the user login code which was made available to the user during registration. This is the only condition for accessing the platform for voting; afterwards the system will verify the voter’s status (voted or not voted) based on the election taking place. If the voter has not voted, the voter will be allowed to vote for the party of his/her choice, else access will be denied to the voter. When a voter has voted, he/she will immediately receive an SMS as feedback stating its vote status and at the end of the polls the voter will also gets the collated result of the election through an SMS.

**System Database Design**

A system of this magnitude often has to do with content management, which often supports qualitative content using metadata values. These metadata values cover technical information like the name of the user, date of birth, occupation, phone number, state of origin, Local Government Area, registration area etc. Here, the database was designed to efficiently hold such metadata values in database objects called tables.The following design parameters were put in place while designing the database.

1. The database size
2. Access time of the database

In designing this database, the first thing done was to understand the process of the proposed system. Table 1 to Table 4 shows the database design for the Voter table, Election table, voting table and result table.

**Table 1: Voter Database**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Serial** | **Column/Field Name** | **Data Type** | **Size** | **Description** |
| 1 | Sn | Int | 10 | Assigns unique serial number to individual records |
| 2 | Voter\_id | varchar | 15 | Holds the id of the voter |
| 3 | Voter\_name | Varchar | 200 | Holds the name of the voter |
| 4 | Ward | Varchar | 100 | Holds the ward of the voter |
|  | Phone no | Int | 11 | Holds the phone number of the voter |
| 5 | Lga | Varchar | 100 | Holds the local government of the voter |
| 6 | State | Varchar | 50 | Holds the state of the voter |
| 7 | status | Int | 2 | Holds the status of the voter |

**Table 2: Election Table Database**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Serial** | **Field** | **Type** | **Size** | **Description** |
| 1 | Sn | Int | 10 | Assigns unique serial number to individual records |
| 2 | Election\_type | Varchar | 50 | Holds the election type (presidential, gubernatorial etc) |
| 3 | Election\_date | datetime |  | Holds the election date |
| 4 | Number\_of\_candidates | Int | 3 | Holds the number of the candidates |
| 5 | Election\_status | Int | 2 | Holds the election status (Done or still on) |

**Table 3: Voting Table Database**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Serial** | **Field** | **Type** | **Size** | **Description** |
| 1 | Sn | Int | 10 | Assigns unique serial number to individual records |
| 2 | Voter\_id | Varchar | 15 | Holds the id of the voter |
| 3 | Candidate\_voted | Varchar | 50 | Holds the candidate voted for |
| 4 | Election\_type | Varchar | 50 | Holds the election type |
| 5 | Election\_date | Datetime | 10 | Holds the election date |

**Table 4: Result Table Database**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Serial** | **Field** | **Type** | **Size** | **Description** |
| 1 | Sn | Int | 10 | Assigns unique serial number to individual records |
| 2 | Election\_type | Varchar | 50 | Holds the election type |
| 3 | Total\_vote\_count | Int | 10 | Holds the total vote count |
| 4 | Election\_date | Datetime |  | Holds the election date |

In the implementation of this system, the following administration tools were used:

1. Adobe Dreamweaver
2. SMS enabler
3. MySQL Server
4. Apache Web Server
5. Android Studio
6. SMS gateway

**Development Platforms**

The proposed model of the real time short message service based voting system is written with PHP and HTML programming language in Adobe Dreamweaver and as such can run on any system. The platform offers reusable services common to cloud computing applications, allowing developers to focus on the logic specific to their application.

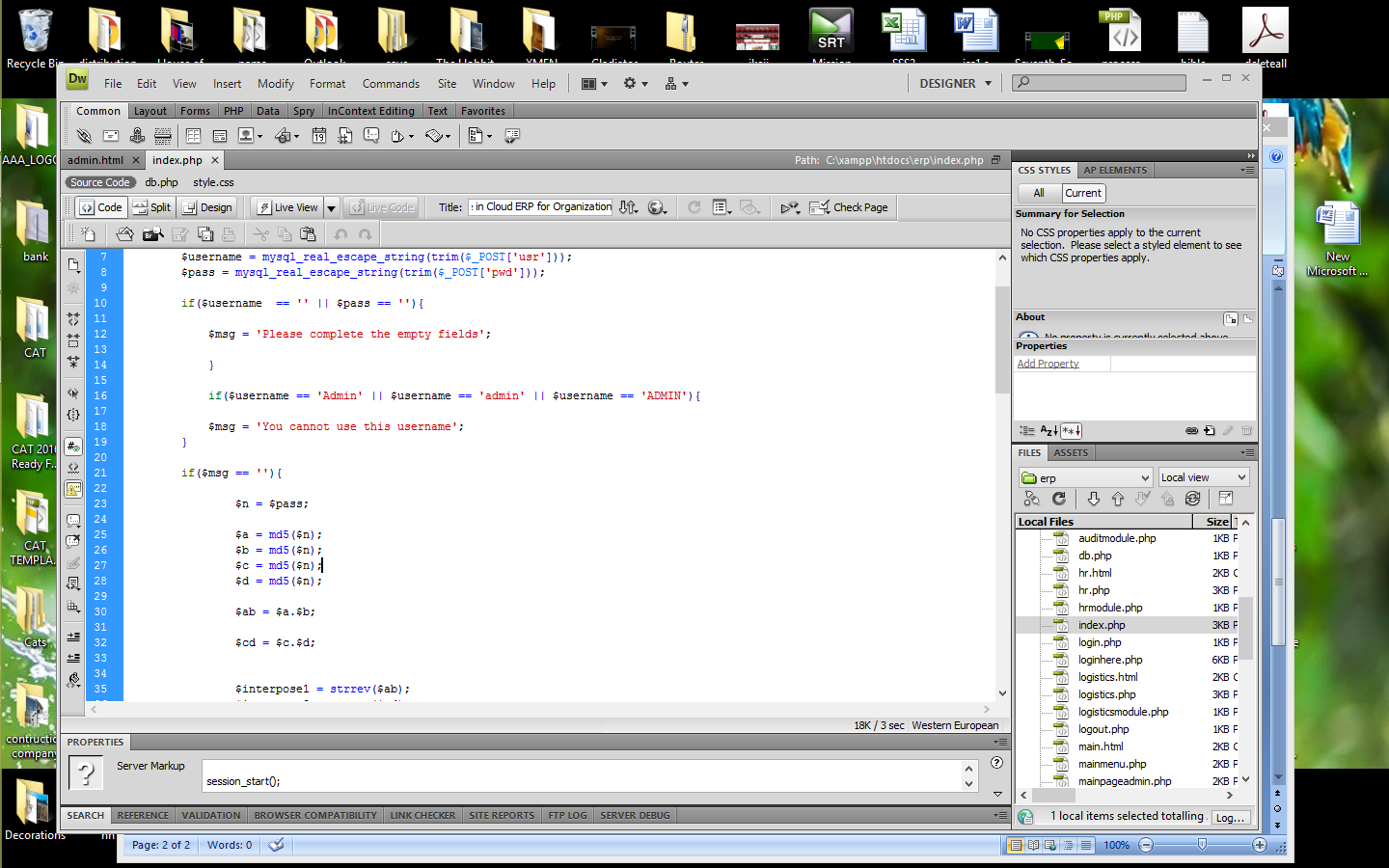


Figure 3: System’s Coding Pages

**RESULTS AND DISCUSSION**

The figures below show the snapshots of the interfaces of the real time Short Message Service based voting system. These interfaces make voting possible. Figure 4 shows the snapshot of the voter Registration and Login Interface.

|  |  |
| --- | --- |
|  |  |

Figure 4: Voter Registration and Login Interface (Web and Mobile Respectively)

This interface enables a voter to be registered by an electoral officer before the voter can be allowed to cast his or her vote. This is done online by the electoral officer. Then on a successful registration the voter is given a unique code, which serves as his login code. Through the login interface, the voter is either granted or denied access to the voting interface.

|  |  |
| --- | --- |
| A screenshot of a computer  Description automatically generated | A screenshot of a computer  Description automatically generated |

Figure 5: Sample Voting Interface and Feedback

Figure 5 shows the snapshot of the Voting Interface and feedback. This interface allows the selection of the election type e.g. presidential, gubernatorial, senatorial etc. A feedback message gotten for each successful vote casting. Figure 6 shows the snapshot of the admin interface for the election vote count and summary. With this platform, the election summary can now be sent to the voters at the end of the election.

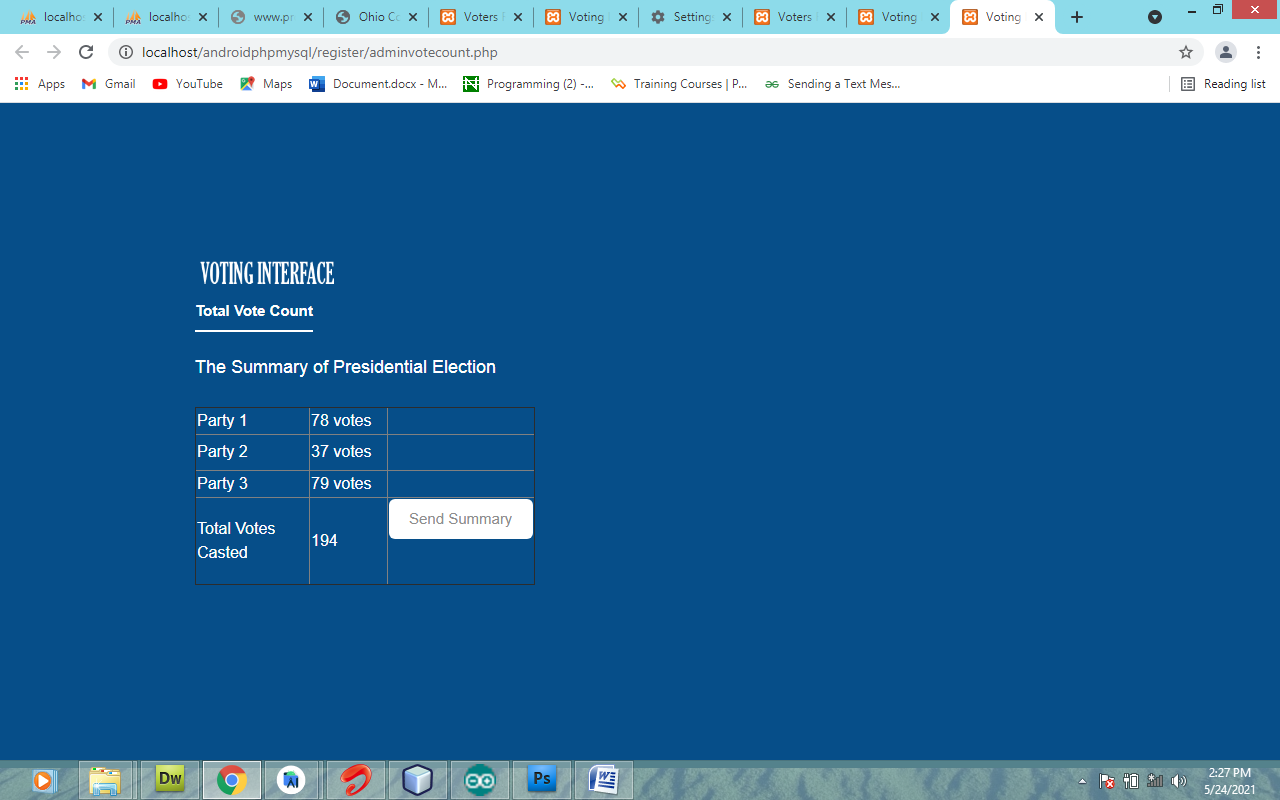


Figure 6: Sample of Admin interface for Election Vote Count and Summary

Table 5 shows the latency for each successful vote cast for both the existing e-voting system and that of the real time Short Message Service based e-voting system respectively.

**Table 5: Latency for each successful vote cast for existing e-voting system and the real time Short Message Service based e-voting system**

|  |  |  |
| --- | --- | --- |
| **Number of trial (N)** | **Existing e-voting system (sec)** | **Real Time Short Message Service based e-voting system (sec)** |
| 1 | 32.01 | 42.02 |
| 2 | 31.40 | 41.42 |
| 3 | 31.51 | 41.50 |
| 4 | 32.00 | 42.00 |
| 5 | 32.01 | 42.01 |
| 6 | 31.42 | 42.02 |
| 7 | 31.44 | 41.55 |
| 8 | 31.50 | 41.51 |
| 9 | 31.45 | 41.56 |
| 10 | 31.47 | 41.50 |
| **Total average** | **31.62** | **41.71** |

**Performance Evaluation of the Real Time Short Message Service Based E-Voting System**

The developed real time short message service based e-voting system was evaluated by comparing its availability on demand with that of the existing e-voting system. The real time short message service based e-voting system success rate which is a function of the system’s availability is the same as the existing system. This means that the SMS feedback features incorporated in the real time short message service based e-voting system had zero (0) impact on success rate.

On the other hand figure 7 shows the latency of both systems, it can be seen that the real-time short message service-based e-voting system introduced an average delay of 41.71 seconds into the e-voting system.

Transparency and availability are key performance indicators for evaluating an e-voting system with transparency being of more critical importance. Most e-voting systems can tolerate a maximum latency of 60 seconds for each successive vote cast. It can be seen that the latency of the existing e-voting system on a scale of 60 seconds is 52.7% giving a tolerance of 47.3%. The latency of the new system is 69.5% giving a tolerance of 30.5% and with a difference of 16.8% (introduced latency by the new system), when compared with the existing system. Since 16.8% is less than 47.3%, this means that the introduced latency as a result of the SMS features of the real-time short message service-based e-voting system still falls within the tolerance region of the existing e-voting system.

Figure 7: Comparison of Latency for Successful Voting for the Existing and New E-Voting System

**CONCLUSION**

This research work has designed and simulated a real time short message service based e-voting system. Hypertext Preprocessor (PHP), Hypertext Markup Language (HTML), Structured Query Language (SQL) were used in the coding, while the running of the application was done using the Apache Web server. With this re-engineered architecture and inbuilt SMS features, this system can perfectly bring election malpractice to an end as well as making electoral processes transparent, free and fair.

Cloud computing technology is still relatively new in terms of maturity and adoption. The expectation is that it will undergo several changes in the future, in terms of resources, issues, risks, and ultimately best practices and standards. However, there are some great advantages offered by cloud computing to e-voting. Again, this developed system is an application developed for better and effective election monitoring and management, which is designed to curb electoral fraud that is on the increase. The system when accepted and deployed will end the era of electoral fraud and will give way for a constant and consistent free, fair and transparent election in Nigeria and the world at large. This paper having understudied cloud computing types and delivery models and various limitations of existing e-voting systems, now concludes that a robust e-voting architecture with SMS incorporation will be optimized e-voting systems.

The following were the contributions made in this work:

1. Development of a real-time short message service (SMS) based e-voting system for efficient and transparent electoral processes.
2. Incorporation of strong security measures in the system to prevent electoral fraud.
3. Developing a more effective e-voting system by leveraging Android technology.

The work presented in this paper indicates that there are more areas that can be improved for further study such as facial recognition authentication, improved scalability and fault tolerance, online viewing and optimized TCP.

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