

1 Developing an Application Program Interface (API) for Both Single and Bulk Spatial Query Capabilities and Automated 2 Voting in Jos South LGA of Plateau State, Nigeria!

3 Abstract

4 Election maleficent and the after-math of court litigations particularly, the 2019 and that of 2023 elections whereby, courts
5 (which is usually at the beck-and-call of the incumbent) decides who won the ballots casted by the electorates in Nigeria; has
6 lingered over time. The essence of this paper is to develop an Application Program Interface (API) which is user friendly with
7 either simple or android phone for both single and bulk spatial query capabilities and automated voting using Jos South LGA
8 of Plateau State, Nigeria as a proto-type. The proposed e-Voting system was designed with the goal of solving optimal
9 challenges encountered by the traditional balloting; and some of which include precise rule-based on eligibility
10 determination, appropriate module, robust access list creation and management as well as remote balloting. The application
11 relies on the file geo-database obtained from National Population Commission (NPopC) but compatible with Relational
12 Database Management System (RDBMS) on MySQL file format and the list of districts wards, localities, PUs and service area
13 or routes to determine where each eligible voter's vote shall be tallied. This solves the distance barrier that has denied many
14 citizens from exercising their civil rights. Age and nationality are two other major factors used by the application to determine
15 the eligibility of voters. The relationship among various entities in the database model is either one-one or one-many in a
16 MySQL file format. The file geo-database (FGDB) obtained was for ease of integration into the three ends of the API. The
17 WampServer being the 'Desk-Top Server' at the back end of the app controlled by the dBA; the mid-end is between the front-
18 end and the dBA that convey all transactions; and the front-end is exclusively for the voter. But all operations are monitored
19 and under the control of the database administrator (dBA). Each of this end is being managed by specific module interactively
20 and seamlessly and robust enough to carry all election stakeholders along in election transactions before, during and after the
21 election results are displayed with the RF-ID of the dBase, which is managed by the third party as it is done in other clients.

22 Keywords: WampServer, MySQL, dBA, FGDB, RF-ID and Module

23 1. Introduction

24 The dilemma of Nigeria's election and the quest for effective system of voting, policy makers in the country begin to advocate
25 for e-voting as an alternative to the traditional ballot system that lacks transparency, loss of confidence and trust in electoral
26 process; and other electoral related issues that characterized the voting system in the country [1, 3, 4].

27 Prior to the 2015 general election in Nigeria, the then chairman of Nigeria's Election Management Body (EMB), Prof. Attahiru
28 Jega introduced 'Card Reader Machine' technology for validating the bio-metric data of an eligible voter on Election Day
29 before casting ballot [5, 6, 10]. Unfortunately, it was frustrated on 'Election Day', it could not authenticate the finger print of
30 the incumbent President Goodluck E. Jonathan [7]. There was the issue of latency in matching the finger print with the facial.

31 The quest to make Nigeria election more credible and transparent made the INEC introduce the BIVAS technology which has
32 been around for some time, it was first tested in the Isoko South Constituency 'Bye-Election' in Delta State, Sept 10TH, 2021,
33 10TH Feb, 2023 [9]. But, the BVAS was meant to perform three functions namely; bio-metric accreditation of voters before
34 ballot, to snap the polling unit result sheet (form EC-8A) after collation and duly signed by all polling agents; then transmit
35 such result to INEC result portal (IREV) [[10].

36 But, in the 2023 Presidential and National Assembly elections, the BIVAS that could not transmit the presidential election
37 result to the IREV was able to transmit that of the Assembly election results from the same polling unit [9, 5]. What an irony!
38 INEC's says, there was a 'Technical Glitch' at the point of transmitting the Presidential result to the IREV portal, as it was
39 reported on one of the popular electronic media [6, 5]. It is against the background of the aforementioned that this paper seeks
40 to develop an application that shall interface for small and bulk query capabilities and automated voting [5] for both single and
41 bulk users; and the app be protected with anti-spoofing from would be hackers.

42 2. Related work

43 It is pertinent therefore, to introduce the conceptual framework for the app; the anticipated e-Voting system was designed with
44 the goal of solving optimal challenges faced by the traditional approach to balloting [4, 5, 6]. This include a precise rule-based
45 on eligibility determination module, robust access list creation and management, as well as remote balloting [5]. The
46 application relies on a database with the list of states, their local governments, districts and Wards to determine where each
47 eligible voter's vote shall be tallied [7]. This solves the distance barrier that has denied many citizens from exercising their
48 civil rights. Age and nationality are two other major factors used by the application to determine the eligibility of voters [9].
49 The relationship among various entities in the database model is either one-one or one-many [11]. For Nigerians in the
50 diaspora wanting to vote during election Nigerians outside the country can still vote, only if they have a Nigeria address and or
51 fly home to cast their ballot [13], which most people cannot afford. The Abuja based Nigerians in Diaspora Commission says
52 further that; Nigerians abroad sent more than 20 billion dollars back home in 2021, the highest in sub-sahara Africa in 2023

53 [13]. It is justifiable therefore to allow them vote seamlessly since their yearly remittances is significant enough to positively
 54 affect the country's gross domestic product (GDP). The former INEC boss Prof. Attahiru Jega in the aftermath of the 2023
 55 elections says, the pundits are afraid of technology, because it will bring sanity in the entire election processes [[10]. However,
 56 the technology is not without challenges; but investigations revealed that, majority of the problems are man-made.

57 3. Material and Method

58 3.1. Material

59 The material required to prosecute the objective of this article was obtained from the file geo-database of the National
 60 Population Commission (NPopC), which is compatible to MySQL file format for ease of integration into file geo-database of
 61 ArcGIS and dis-aggregated into needed different data-types and attributes (data structure) for analysis. Then the geo-coded
 62 residential addressess of all eligible voters be also integrated into the file geo-database. Table 1 below is a sample of material
 63 obtained from the NPopC.

64 **Table 1.** dBase Sample.

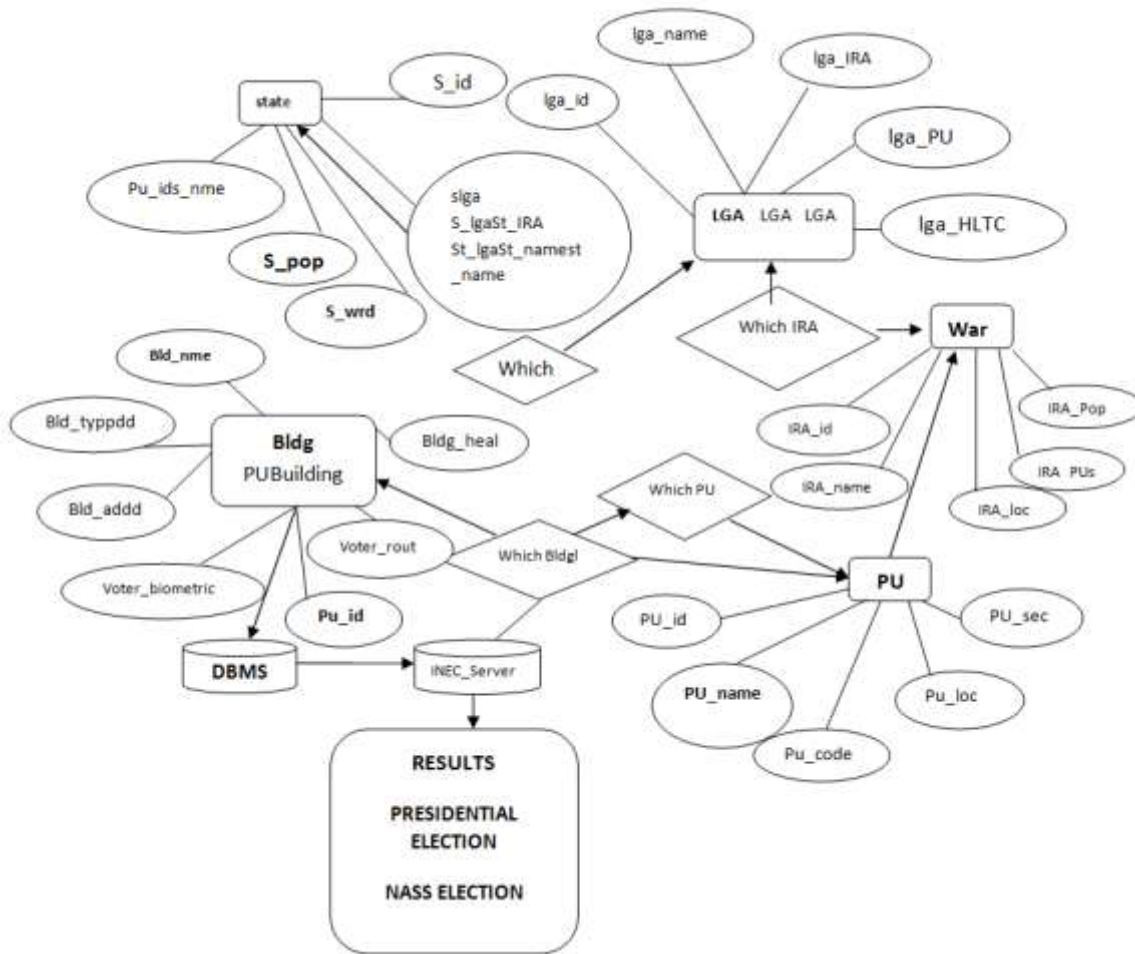
Natio nality	State_ Name	State_ Code	LGA_ Name	LGA_ Code	Loc_ Name	Loc_ Code	IRA_ Name	Bldg_ Code	IRA_ Code	PU_ Code	Pop_ Loc	Gen der	A ge	B C
1	Plteau	23	Jos South	73	Fwati	10	Zawa n 'A'	1601	11	1	6753	M	1 9	Y
1	Plteau	23	Jos South	73	Fwati	10	Zawa n 'A'	1602	11	1	6753	M	2 3	Y
1	Plteau	23	Jos South	73	Fwati	10	Zawa n 'A'	1603	11	1	6753	M	3 0	Y
1	Plteau	23	Jos South	73	Fwati	10	Zawa n 'A'	1604	11	1	6753	M	2 7	Y
1	Plteau	23	Jos South	73	Fwati	10	Zawa n 'A'	1605	11	1	6753	F	4 3	Y
1	Plteau	23	Jos South	73	Fwati	10	Zawa n 'A'	1606	11	1	6753	F	4 0	Y
1	Plteau	23	Jos South	73	Fwati	10	Zawa n 'A'	1607	11	1	6753	F	3 9	N
1	Plteau	23	Jos South	73	Fwati	10	Zawa n 'A'	1608	11	1	6753	F	5 4	N
1	Plteau	23	Jos South	73	Fwati	10	Zawa n 'A'	1609	11	1	6753	F	5 8	
1	Plteau	23	Jos South	73	Fwati	10	Zawa n 'A'	1610	11	1	6753	F	4 7	Y
1		23	Jos South	73	Fwati	10	Zawa n 'A'	1611	11	1	6753	F	4 1	Y

65 Source:National Population Commission (NPopC) Abuja, (2024).

66 3.2. Method

67 The following steps were taken in order to develop the API for both single and bulk spatial query capabilities and automated
 68 voting in Jos South LGA of Plateau Stae; Step 1: Application Configuration Assigning a voter to a specific voting or polling
 69 unit, require an application program interface with three different ends namely; the front, mid and the back end respectively.
 70 The front end was developed using HTML, JavaScript, and CSS. HTML were used in order to assist in quickly separating
 71 marked texts from un-marked texts, and for ease of sorting and validating a voter before voting; while CSS separates contents
 72 like layout colors, fronts and improve control over the contents when matching voter's photograph with the finger print before

73 voting; and the JQuery is the module that allows for voter’s interactions at the front end seamlessly. Some elements of JQuery
 74 were added to make the application more interactive and user-friendly. The front-end is the interface which allow qualified
 75 citizen register and also permit registered voters to perform their civic right in a designated polling or voting point. It also
 76 allow the application administrator to create various configurations, schedule elections and also generate various reports; such
 77 as voters register of all eligible voter, their district, voting point (polling unit) and location; in terms of locality name, etc.
 78 Figure 1 below shows the internal structure of the database model:



79
 80 **Figure 1.** Mental Abstraction of the Apps Database.

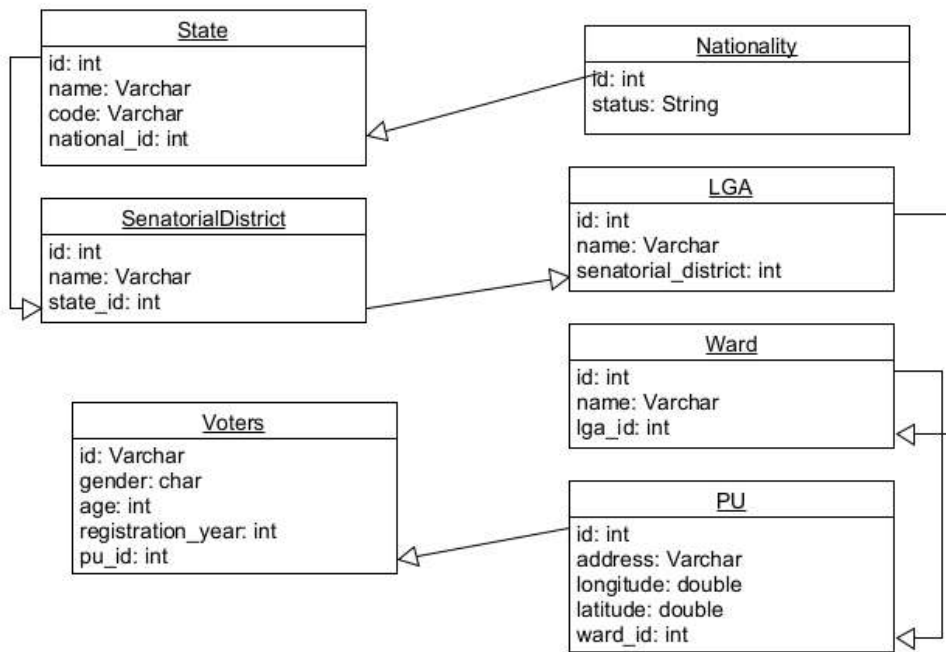
81 **Source: Author’s Field Work (2024)**

82 **Step 2: Module to Convert Geo-database File to CSV format**

83 In order to integrate file geo-database model of table 1 above which was in excel file format, it was subsequently converted to
 84 CSV file format. This format fits easily into MySQL language used in developing the application (app.). The biometric
 85 capturing and matching module involve high computational cost of image template matching which require high end server; as
 86 such the anticipated application program shall only explain how the module works.

87 **Step 3-Entity Relationship**

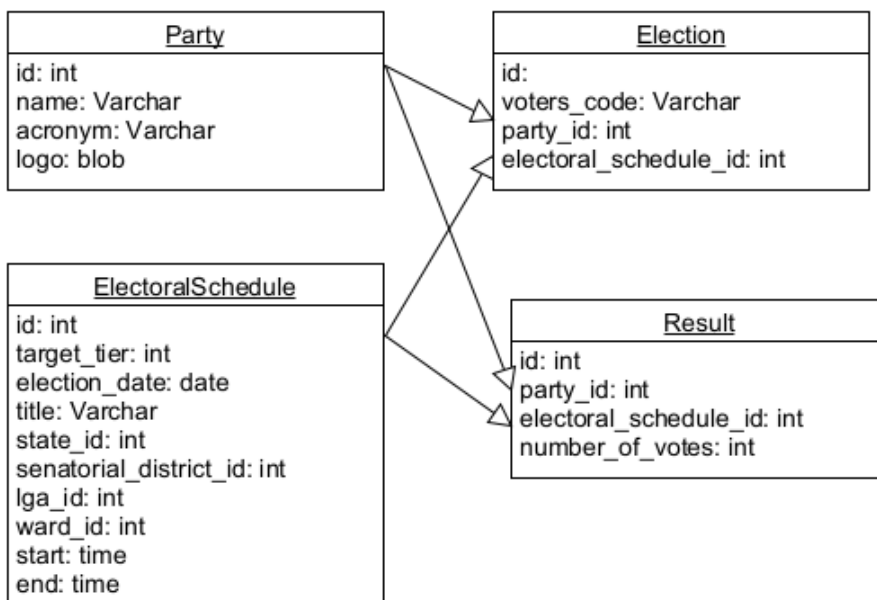
88 The figure below is the schema of the implicit interactions of different layers of election data collected and analyzed at the
 89 back-end of the app. The relationships were all defined and their attributes.



90
91 Figure 2. Entity-relationship (E-R) diagram for voters' registration.

92 Source: Author's Field Work (2024)

93 For each election into various office, the administrator (dba) creates both setup and schedule. The setup process involves the
94 definition of political parties contesting an election, the post being contested, and the association of such post to either national,
95 state, senatorial district, local government area, or ward. The database model for an electoral setup is as delineated in figure 3
96 below. This model supported and serve as interface between the database structure (E_R) schema and the voter.



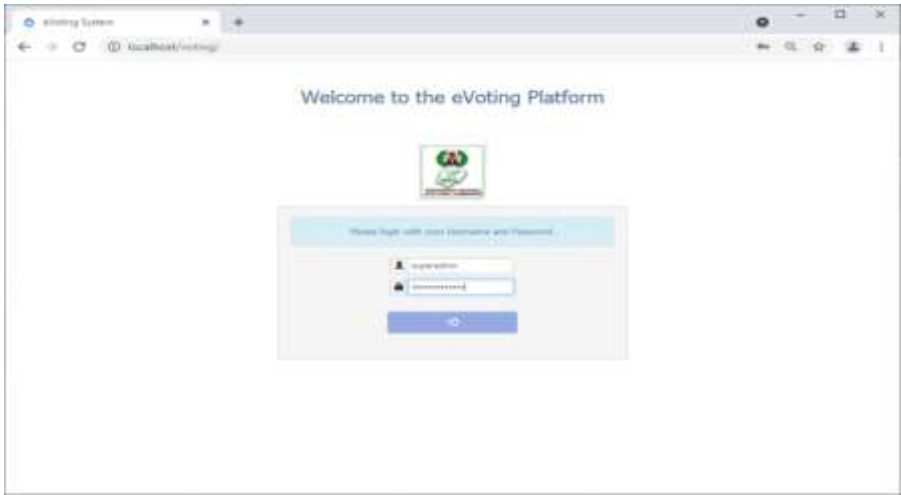
97
98 **Figure 2.** Interface between dba and the Voter

99 Source: Author's Field Work (2024)

100 **4. Results and Discussions**

101 Output 1: Entry Point to the app

102 Figure 5 below is the screen-shot of the main entry point to the app from the dBA Admin (code=admin). The dBA admin signs
103 into the app using 'admin' as user name and any two or three digit numeric code (1 2 3). This shall take the operator to the
104 'super admin' phase. See figure 6 below:

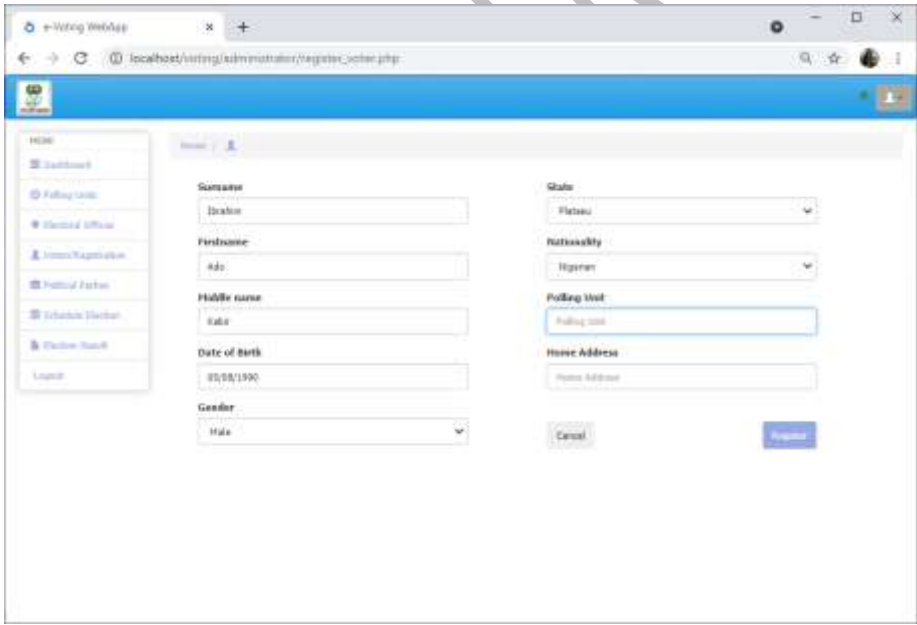


105
106 Figure 3. Super Admin phase (dBA)

107 Source: Author's Field Work (2024).

108 **Output 2:Voter's Registration**

109 Before an eligible voter is assigned or have a designated voting point or polling unit nearest to his or her residence, such person
110 must be captured in the voting program designed, all the biometric capture, residential address, nationality, state, LGA, name
111 and other relevant data. The voter's registration page provides an interface through which eligible citizens' details are captured
112 and stored in the system. This include the surname, first name, middle name, date of birth, gender, phone number, state of
113 origin, senatorial district, local government area, and ward. To make entry easier, a relation has been defined such that for any
114 given ward code, the name of the ward, the local government where it is located, the senatorial district, and the state, can easily
115 be retrieved. Each registration officer is assigned a particular ward. Hence, by default, any voter registered by such registration
116 officer is added to the list of eligible voters for the ward. See Figure 7 below;



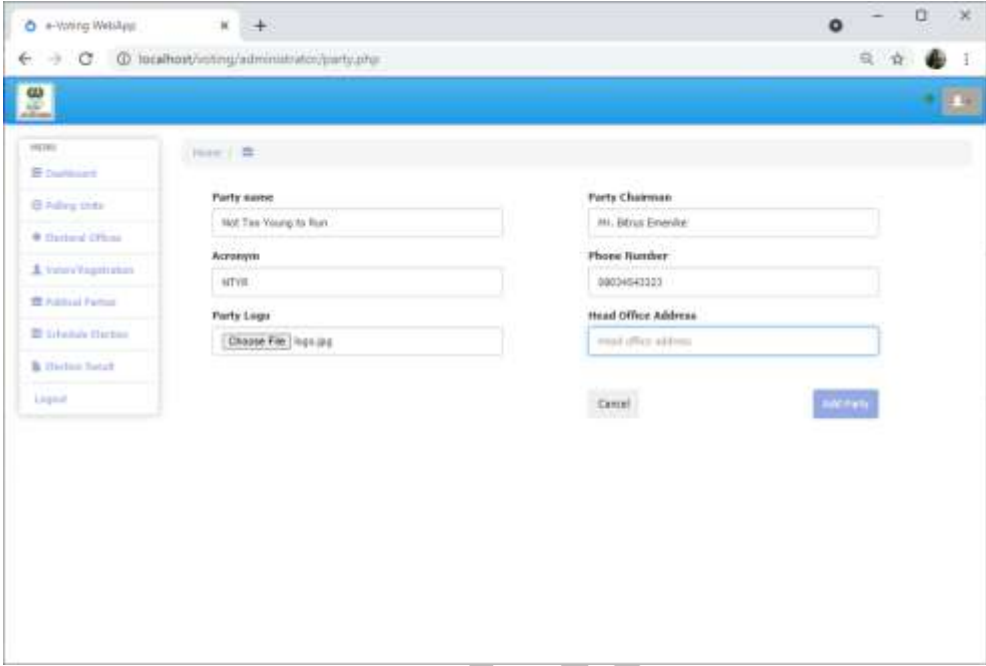
117
118 Figure 4. Voter's Registration Module

119 Source: Author's Field Work, (2024).

120 **Output 3: Procedure for Voter Verification and Vote Casting**

121 The process is initiated when the electorate presents themselves for verification. The basic assumption is that the Polling unit
122 that the voter approaches was designated and for verification and also have internet facility for real time verification. The
123 verification exercise follows the tradition verification process in which the voter's card and fingerprint are matched with the
124 database of eligible voters. In order to reduce the latency, template matching is limited to users within the polling unit of the
125 voter since the residential address was geo-coded. If the verification process is successful, the voter can then proceed to the
126 voting interface with a unique code generated by the server.

127 The web content was specified using HTML while the application layout was structured using CSS. The web template used is
128 responsive thereby allowing easy access of the application from hand-held devices such as mobile phone and custom displays.
129 See sample of the database in Table 8,1. Usually, the application was pre-loaded with data and information obtained from the
130 file geo-database of ArcGIS; then filtered by HTML and CSS before use. The data forms the basis for registration of voters
131 and validation, election schedules, and collation of election results.

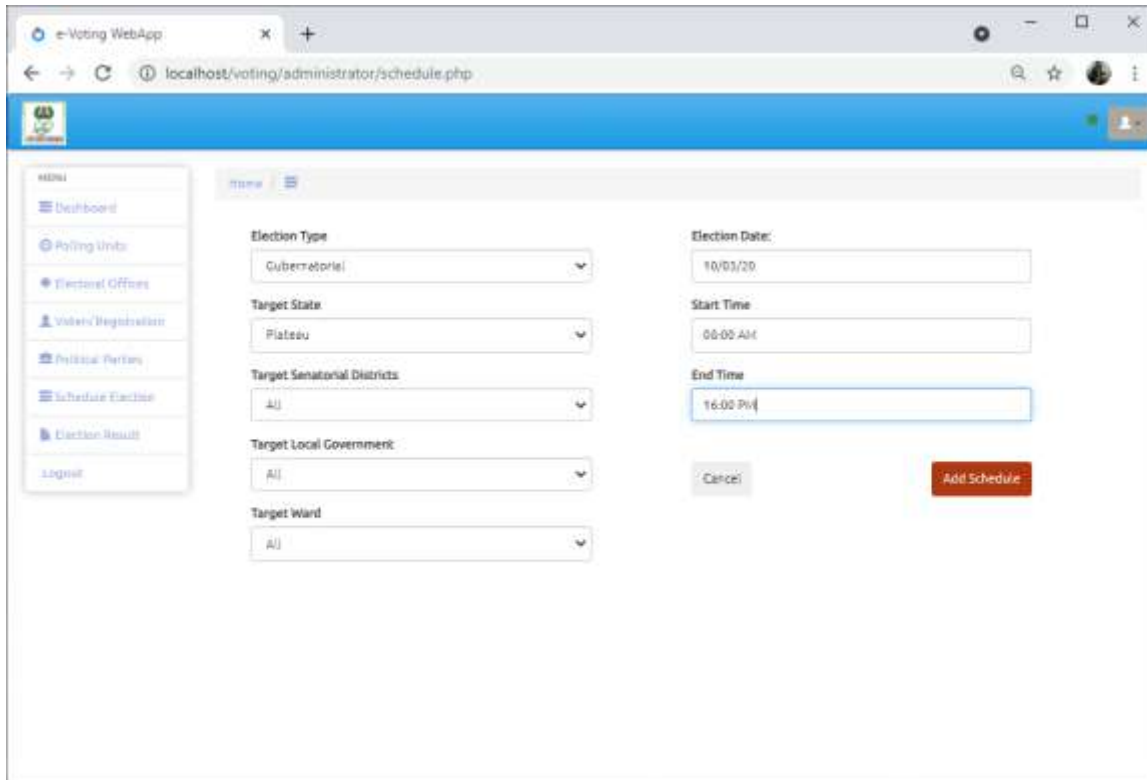


132
133 Figure 5. New Party Registration Platform

134 Source: Author's Field Work, (2024)..

135 **Output 5: Election Schedule**

136 After successful registration of voters and political parties, the administrator can then proceed to schedule an election. The
137 process of scheduling an election involves the definition of the Offices involved in the election, for example, in a Presidential
138 and Senatorial election. The administrator can then specify the targeted audience which could be one or more wards, one or
139 more LGAs, one or more senatorial districts, one or more states, or the entire nation. The flexibility factored into the design at
140 the phase is to ensure that the proposed framework is relevant for conducting general elections, state-bound elections, and even
141 re-run elections that are to be carried out at selected polling units. The scheduling process involves the specification of the
142 office (e.g. Presidential), the list of ward where the election will be carried out, the scheduled date, start time, end time and
143 schedule status. For elections that are cancelled or postponed, the status is set to -1, 0 for schedules that yet to start and 1 for
144 schedules that have been conducted See screen-shot of the platform:



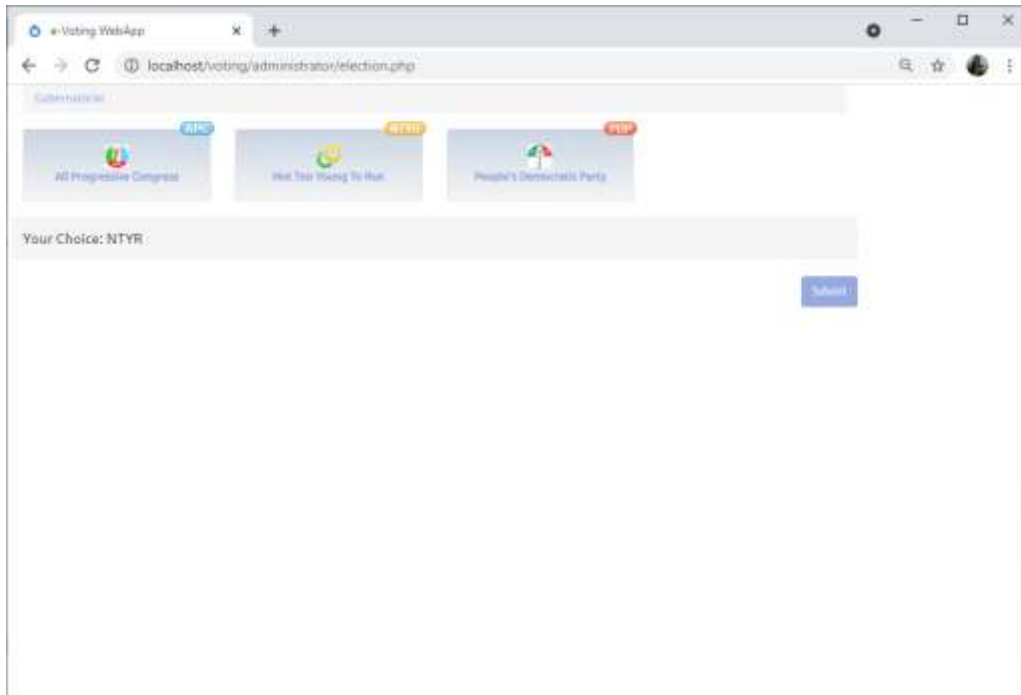
145

146 Figure 6. Election Operator’s Platform.

147 Source: Author’s Field Work, (2024).

148 **Output 6: Vote Casting**

149 The process is initiated when the electorate presents themselves for verification. The basic assumption is that the Polling unit
 150 that the voter approaches for verification has internet facility for real time verification. The verification exercise follows the
 151 existing tradition verification process in which the voter’s card and fingerprint are matched with the database of eligible voters.
 152 In order to reduce the latency, template matching is limited to users within the polling unit of the voter. If the verification
 153 process is successful, the voter can then proceed to the voting interface with a unique code generated by the server. In this
 154 research, a simple web interface has been developed. This can be extended to mobile application, with support for multiple
 155 platforms, and specially built handheld devices. The voting platform accepts as input the user’s voters’ ID and a unique code
 156 generated from the server during verification. As an additional layer of security, a two-factor authentication scheme has been
 157 incorporated into the design. Once the voters’ ID and unique code has been verified, the application generates and sends a PIN
 158 to the phone number associated with the voter’s detail, to mitigate the possibility of Voters’ card theft. The generated PIN is
 159 then used for the 2FA. After successful verification and authentication, the application displays the list of concurrent elections,
 160 if more than one election is on-going. User can click on the choice post and a list of political parties, having aspirants for such
 161 post, is displayed. After the voter’s choice has been made, the browser transmits it to a central server where the results are
 162 being collated in real time. Communication between the client and the server are encrypted using a symmetric cipher where the
 163 user’s password is the key used for both encryption and decryption at both ends. After the completion of the electoral process,
 164 the electoral officer can end the election before the end-time, provided that there is no more electorate to vote. Result of an
 165 election is made available immediately after the election has been closed for each polling unit while the aggregate result is
 166 updated as new results are computed for completed elections.



167

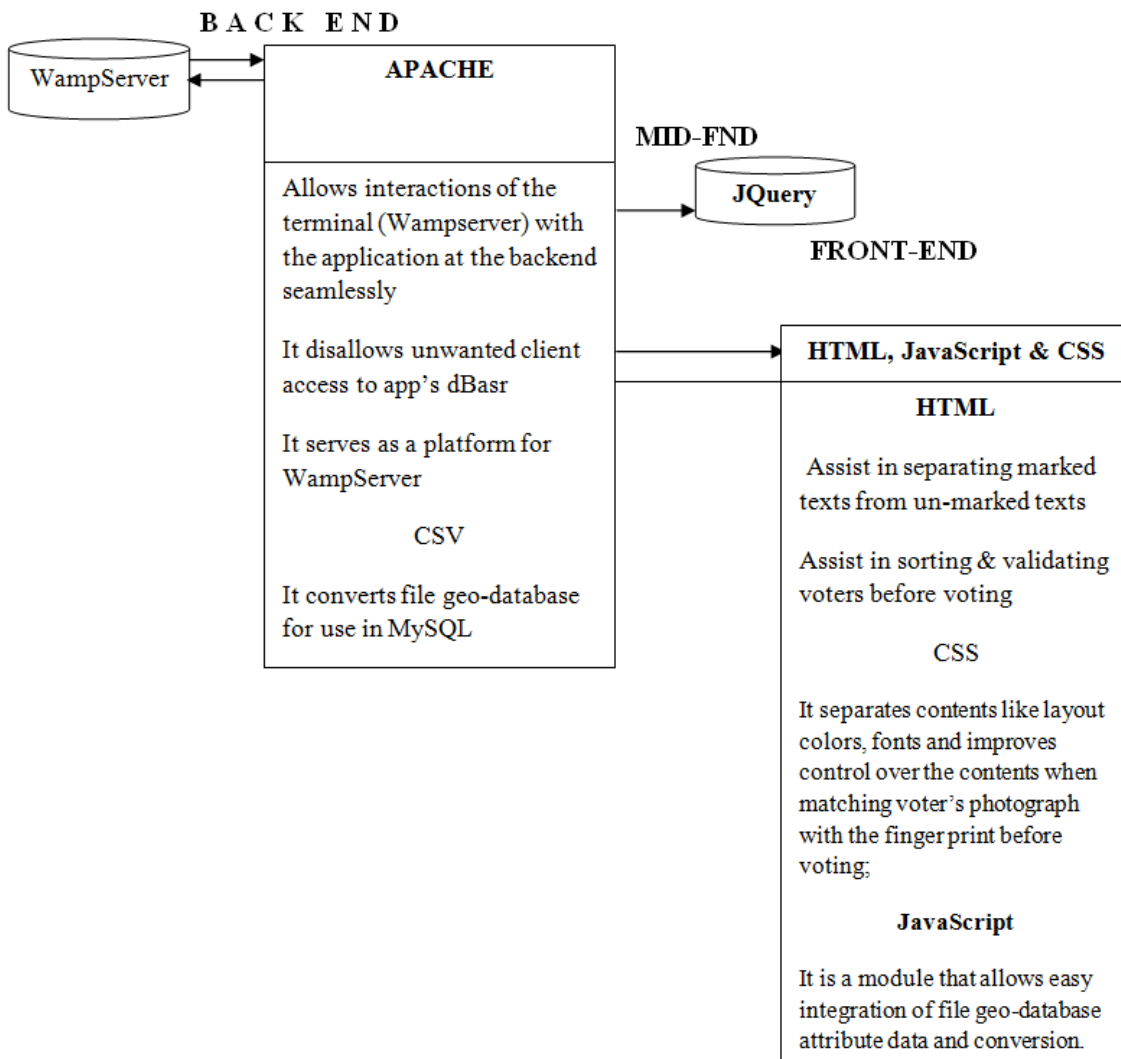
168 Figure 7. Front End Platform

169 Source: Author's Field Work, (2024).

170 5. Conclusion

171 In the nutshell, the developed app for small and bulk spatial query capabilities and automated voting system was as shown in
172 figure 11 below, its internal operations. The app was configured for simple phone not necessarily android but it can be used on
173 Election Day to vote, once a network is available as gate-way.

174 INEC at the LGA level initially may not require internet service to register eligible voters since the WampServer is mobile. But,
175 during election proper, an internet service would be needed. Therefore, the app is expected to reduce to a barest minimum
176 different types of electoral malfeasance, since the number of human operators are reduced drastically. It is also cost effective and
177 all stakeholders are involved in the election process.



178

179 Figure 8: The app's Internal Architecture.

180 Source: Author's Field Work (2024).

181 **NOTE**

182 The RF-ID of this application can best be protected by submitting the entire dBase to a third party proprietor whose main
 183 responsibility is to protect and preserve the integrity and sanctity of the data in the dBase from the would be hackers as it is done
 184 in other clients.

185 **Abbreviations**

- RF-ID:** Referential Identification
- RDBMS:** Relational Database Management System
- HTML:** Hyper Text Mark-up Language

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 190 this study and paid Dr. Lawrence to design the app.

191 **Conflicts of Interest**

192 **No conflict of interest of any kind from any Author.**

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