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Development of a Global Positioning System-Enabled Electronic Voting System

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Abstract: *This paper deals with the design and development of an electronic voting (e-voting) system with Global Positioning System (GPS) device for client service authentication and poll centre co-ordinates monitoring to solve the problem of identifying votes with their corresponding poll centres during and after voting exercise so that voters are assured that their votes are secured. The architecture of the system has three phases; the GPS client service which is interfaced with the system to determine poll centre co-ordinates as well as to serve as the access code to the developed server. The second phase of the system is the client station where eligible voters can register and vote with their captured fingerprint and facial image as unique identity while the third phase of the system is the server where results from various clients are accommodated and processed.*
Keywords: *Election, Electronic voting, Facial Image, Fingerprint, Global Positioning System (GPS) device.*

I. Introduction

Elections are crucial instrument of recruiting leaders by the electorate in a democratic system and a litmus test of a democratic political system [1]. The election has become a great tool in many fields ranging from political to social in modern societies to express people's opinion. It is very important and essential to let the majority of the people elect their preferred candidate. Nowadays, that societies are advanced in all fields of life, it is also necessary to improve and develop the manner of election system. The technology in computer science and communication which has developed dramatically in the last few years as a result of advancement in electronic engineering has contributed to the achievement of modern, quick, accurate and safe election. As a result of this, e-voting is emerging as a significant alternative to other conventional voting systems in the provision of trusted elections.

However, undoubtedly an implementation of e-voting to communities in geographically difficult to reach terrains with poor communication infrastructure, would allow increased access to the voting process. In this paper, we describe the design and implementation of voting via the internet with the use of global positioning system (GPS) receiver finger-print and facial image capture. The electorate's data are collected during the registration process at dedicated polling centres and are stored on a database. During voting, voters are authenticated via comparison of their fingerprints with the already existed fingerprint in the database. Election results are queried from the database and made available on real time basis.

II. Electoral Systems

1. Paper Ballot System

A simple system to first consider is paper ballot. In this system, the voter marks their choices on a paper ballot or cast their votes via thumb printing on a ballot paper and drops it in a ballot box. All known precautions that can be undertaken to prevent error and fraud in a paper ballot system and polling station. In particular, ballots can be deposited in a publicly observed and preferably transparent ballot box. Numbered stubs can be used to help prevent chain voting and secrecy envelopes can be used to guard privacy and anonymity. However, this method is very prone to manipulation as multiple votes could be done secretly by a voter. Also votes could be counted wrongly [2].

2. Vote by Mail

This involves casting of votes by mail. In the postal voting system, paper ballot is given to the voter after he/she is identified by the polling commission. This system is of benefit to the people who may not be physically at the poll site as a result of disability or absence from voting locality [3].

Mail-in votes are trivially subject to bribery or coercion at the level of individual voters. To perform such fraud at a wholesale level, where a small number of people might attempt to damage the system is far more difficult. A corrupt mail courier could only tamper with the ballots that he or she personally handled, and

tamper-resistant features on the ballot or envelope might make such tampering hard to disguise. Once the ballots arrive at the central tabulation facility, fewer people would need to be involved, but stronger security measures can be in place to prevent such fraud. If, for example, ballot envelopes are counted before even being opened, then those counts could be compared, in batches, to the tallies after the batches are scanned and processed [3].

3. Electronic Voting

Electronic voting is emerging as a significant alternative to other conventional voting systems in the provision of trusted elections. Although certain forms of e-voting have been used successfully in a number of countries during the national and local elections, e-voting has not been expansively used in legally binding political elections [4, 5]. A primary concern of any election system, whether done by hand, via computer, or any other mechanism, is that it must provide sufficient evidence to convince the losing candidate that he or she actually lost and to have a system that is accessible to all and easy to use. The administration of elections is a complex task, and there are many factors involved in choosing and using a voting system in addition to security. They include factors such as reliability, propensity for voter error, usability, and cost. Many innovations that have become familiar features of modern elections originated at least in part as a way to reduce election fraud such as tampering with ballots to change the vote count for a candidate or party [6]. Internet use in the e-voting process is very important because it easier for people to participate without any hesitation or effort. We can improve the quality of an e-voting technique by increasing the security level of such system as we explain in the next section.

4. Global Positioning System (GPS)

GPS consists of 24 operational satellites which orbit earth at an altitude of 20,000 meters at a 55 degree orbital plane. One orbit takes 12 hours, so the same satellite flies over the same position on earth twice a day. GPS is in threefold: the satellites, a control network and the user. The control network monitors the state of the satellites correcting possible clock errors, defining their orbits and updating the transmitted information. Signals from a minimum of four satellites are needed to determine an accurate position. Figure 1 illustrates how each satellite gives an area of possible locations on the surface of the earth and how the true position is narrowed down by increased number of satellites [7].

5. GPS Receivers

As the popularity of GPS-use is ever-increasing also the variety of the receivers available for consumers is greater. There are a number of qualities, which needs to be taken into account when choosing an appropriate receiver for mapping purposes. The positional accuracy is important but the sensitivity is even more critical for acquiring signals in challenging conditions. Positional accuracy is the evaluation of the proximity of the location of the GPS location in relation to the true position on earth's surface [8]. Sensitivity refers to the receiver's capabilities of acquiring GPS signals.

Receivers, which pick up both L1 and L2 GPS signals, have increased positional accuracy, since the ionosphere error is corrected [8]. GPS accuracy in the order of 2-5 meters would be good enough for orienteering map making. A 5 meter error in the terrain would introduce 0.5 millimeter error on a 1:10 000 map – less than the size of any of the point symbols and would be hardly noticeable. By using single GPS receiver one can at the moment at the best achieve about 5 meter positional accuracy, depending on the quality of the GPS receiver [9].

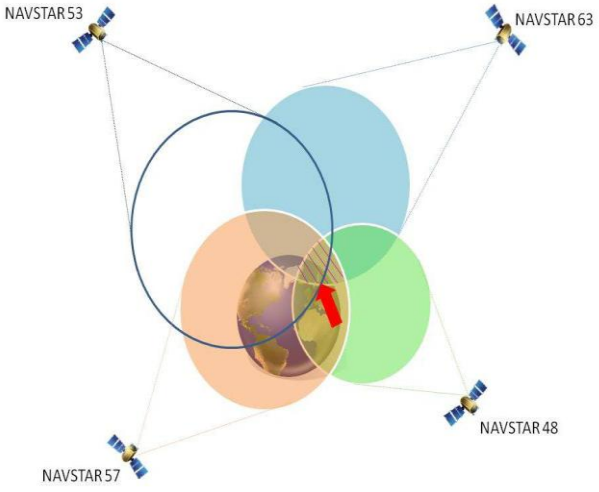


Figure 1: Satellites arrangement for accurate GPS positioning [7].

6. Fingerprint as the most Reliable in Biometrics.

In computer technology, biometrics relates to identity confirmation and security techniques that rely on measurable, individual biological characteristics. Many of these biological characters such as face, fingerprints, voice pattern and iris pattern are peculiar to individuals. One of the most well-known biometric characteristics is the fingerprint. Since the prints on each finger of the same person are different, no two persons have exactly the same arrangement of patterns and, the patterns of any one individual remain unchanged throughout life [10]. Fingerprints have been in use for various purposes ranging from personal identification to criminal investigations for centuries, it happens to be the most reliable and thus sensible to be selected for use if maximum security is to be considered [11]. The validity of fingerprints as a basis for personal identification is thus well established as it's false reject rate and false accept rate happen to be the lowest value of 0.20% among other biometric features.

III. Framework Design

This was done to determine applications architectural framework with suitable middleware for the client-server system. The design requirements of the developed e-voting system in this work are divided into two groups, namely, generic and system-specific. The generic requirements are those requirements that apply to any voting system. The system-specific requirements, on the other hand, are those requirements that are specific to the developed system.

The system architecture defines the key components of the system together with the interactions between these components. The overall functional structure of the framework is summarized as follows: the GPS gives authentication of an accredited poll centre for client-server interconnectivity using the polar coordinates. An eligible electorate registers with the electoral body at a gazette registration centre. The person identifies self by providing all the required bio-data, captured facial image, phone number and the fingerprints of the person will be scanned and stored in the database. The registered electorate will be given a unique voter identification number and a unique voting code which is expected to be confidential to the electorate. Figure below is the model of the developed system.

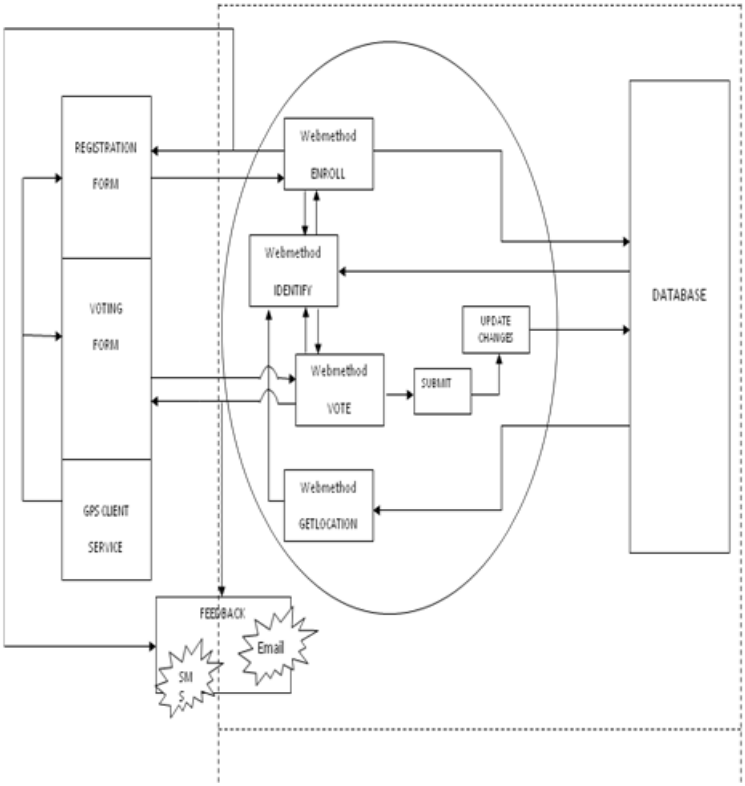


Figure 2: Model of the Developed E-voting System.

The developed e-voting system was designed to allow many voters to vote simultaneously from various centres while ensuring highly availability during the electioneering process. Voters' authentication into the voting system is by biometrics and voting code generated for each voter after registration. Poll site voting requires a fingerprint scan for ballot casting and ballot casted are recorded in the data tables at the backend of the database as binary templates.

The system ensures only one-person, one-vote property of voting systems. The voter's fingerprint is matched at every voting attempt and other information about the voter are displayed to prevent multiple voting. During registration, fingerprints of new electorate about to be registered are matched against exiting fingerprints in the database to prevent multiple registrations.

The overall system was developed based on the derived system requirements and on the .NET framework using Visual C#, and GrFinger SDK (version 4.2). Web applications were developed using ASP. NET while the data tables at the backend in the database server were developed using Microsoft Visual Studio 2010.

IV. Results

Three subsystems are developed to make up this e-voting model. They are the subsystems for the GPS authentication as access to the e-voting system, voters' registration and poll site voting subsystem which interface the electorates to the e-voting system during the registration and voting processes and the application server which host the result from the various subsystems.

1. GPS Authentication Subsystem

The polling center recognition module allows access to be given to the pre-assigned computer system for the polling center from the administrator's end through the GPS scan of the poll site's coordinates. The GPS coordinates are unique latitude and longitude values for every location around the world and these make the various polling centres to have different identities.

At the launch of the e-voting system, the GPS receiver scans the electronic ballot box to synchronize the pre-defined polar co-ordinates of the poll site with the corresponding co-ordinates in the main server database. While the receiver does the scanning and the polar co-ordinates tally, access is gained and if otherwise, the system will decline access in real time and registration exercise cannot proceed. Fig. 3 and 4 depict the GPS authentication module of the designed model.

Movement away from the dedicated poll site automatically leads to change in the polar co-ordinates detected by the GPS receiver of the virtual polling centre and this makes the polar co-ordinates values not to be the same with the value in the main server at the administrator end for authentication. Hence registration or voting cannot proceed.

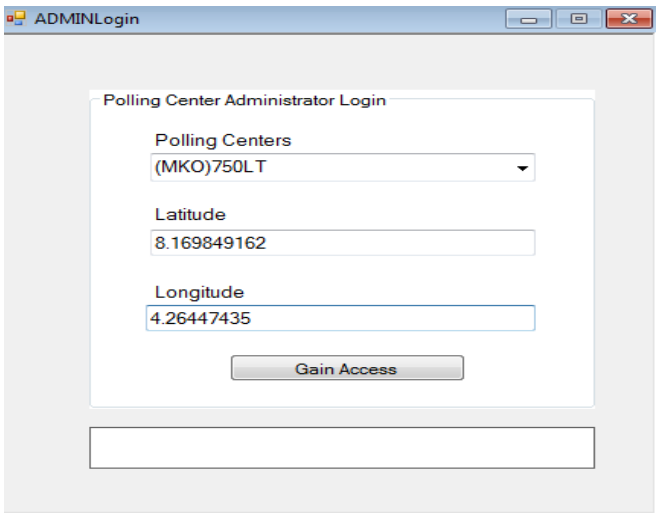


Figure 3: Access Gained through GPS Coordinates

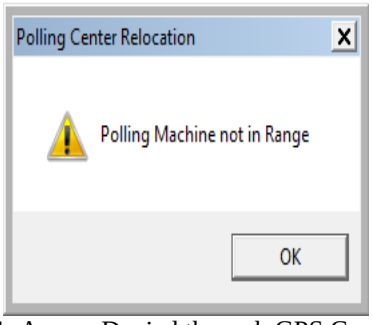


Figure 4: Access Denied through GPS Coordinates

2. Registration Centre and Poll Site Voting Subsystems

The registration centre and poll site voting subsystem is the interface that allows for access into the register voter module, sms notification, accreditation and cast vote module, and Clear module. The Register Voter module allows voters' information to be stored in the system. A legitimate voter's details must exist on the system before such can vote. During the registration process, the picture of each voter is stored against his or her biodata (which must include a valid mobile phone number for feedback) and the fingerprints of the voter are scanned into the system.

After every successful registration, a mobile phone SMS containing voter identification number (voters ID), a voting code and the name of the poll site for registration is sent immediately after registration to voters as receipt acknowledging their registration and same is done at every successful voting as shown in Fig. 4.5

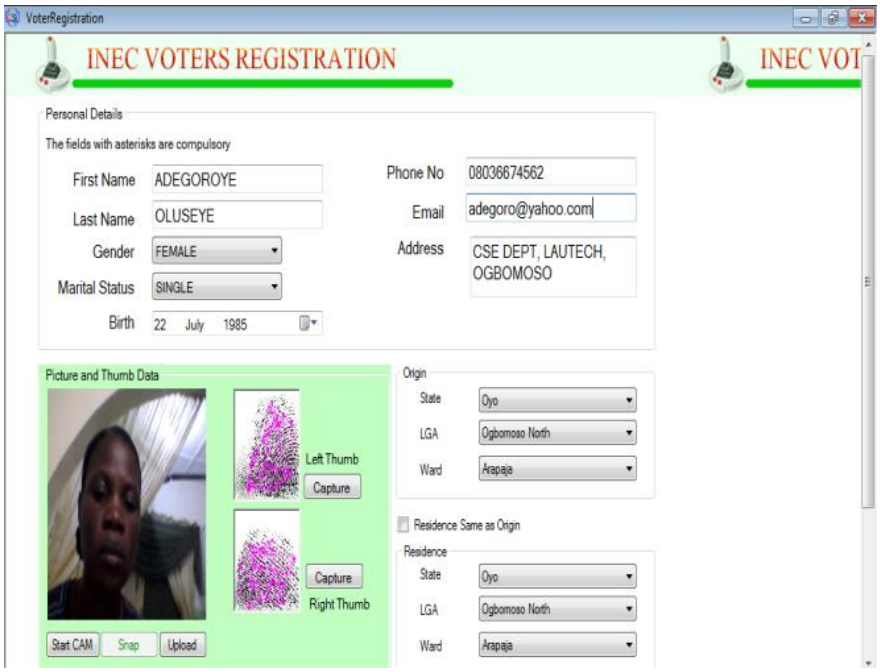


Figure 5: Registration of Voter Module

Figure 6: SMS Acknowledgement of Voter's Registration

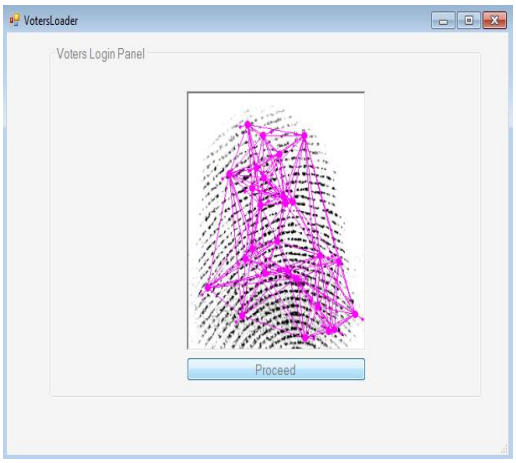


Figure 7: Poll Site Voting Subsystem for Accreditation and Voting.

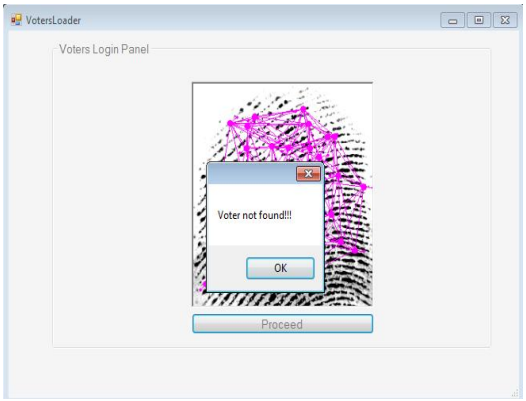


Figure 8: Poll Site Voting Subsystem for Accreditation and Voting.

3. The Developed Application Server

The developed application server is a software framework dedicated to the efficient implementation of procedures (programs, routines, scripts) for supporting the construction of applications. The sever has five menu options, namely New Contestant, Voter's List, Registered Party, Election Process as shown in fig. 9 – 12. The developed e-voting system requires that the Application Sever must be running before any client action could take place.

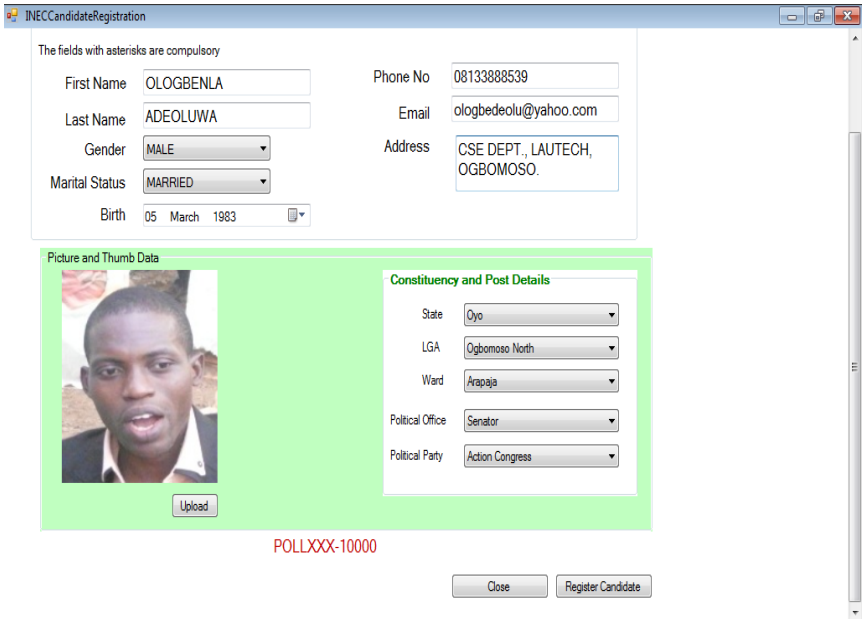
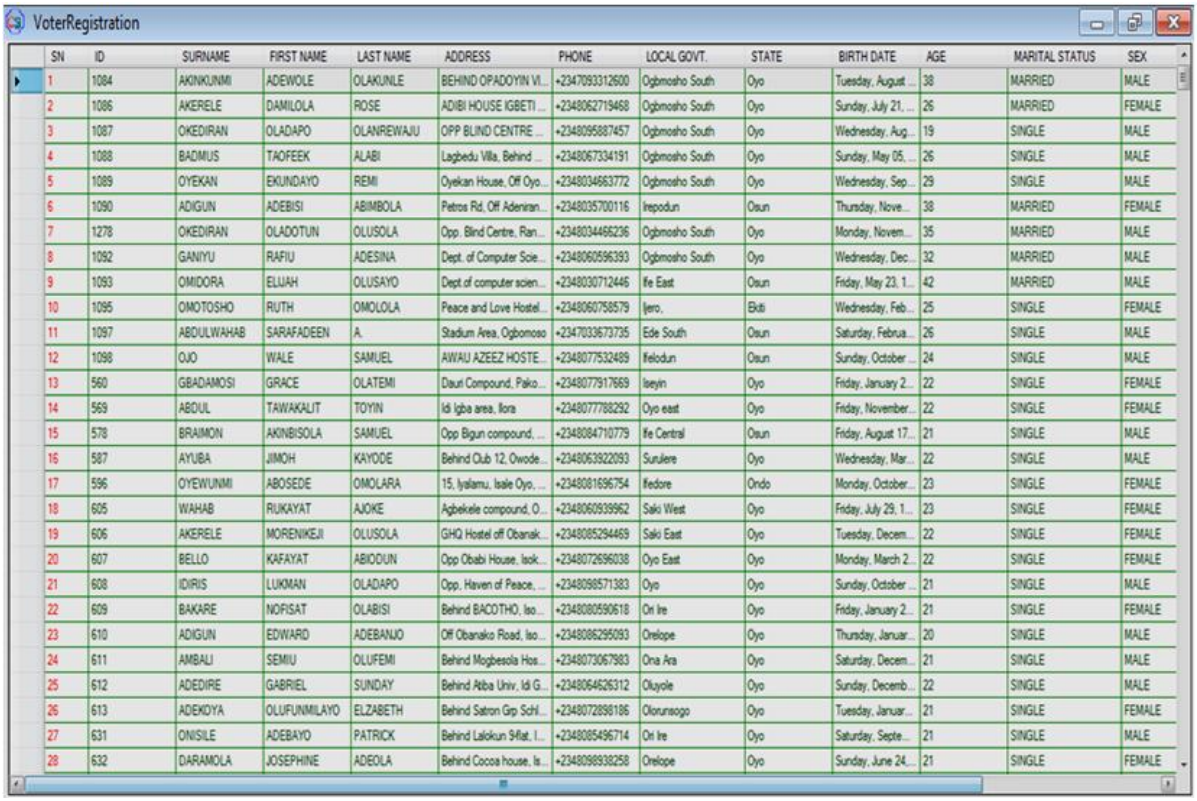


Figure 9: Contestants Menu.



SN	ID	SURNAME	FIRST NAME	LAST NAME	ADDRESS	PHONE	LOCAL GOVT.	STATE	BIRTH DATE	AGE	MARITAL STATUS	SEX
1	1084	AKINKUNMI	ADEWOLE	OLAKUNLE	BEHIND OPADOYIN Vi...	+2347093312600	Ogbmosho South	Oyo	Tuesday, August ...	38	MARRIED	MALE
2	1086	AKERELE	DAMILOLA	ROSE	ADIBI HOUSE IGBETI ...	+2348062719468	Ogbmosho South	Oyo	Sunday, July 21, ...	26	MARRIED	FEMALE
3	1087	OKEDIRAN	OLADAPO	OLANREWAJU	OPP BLIND CENTRE ...	+2348095887457	Ogbmosho South	Oyo	Wednesday, Aug...	19	SINGLE	MALE
4	1088	BADMUS	TAOFEEK	ALABI	Lagbedu Villa, Behind ...	+2348067334191	Ogbmosho South	Oyo	Sunday, May 05, ...	26	SINGLE	MALE
5	1089	OYEKAN	EKUNDAYO	REMI	Oyekan House, Off Oyo...	+2348034663772	Ogbmosho South	Oyo	Wednesday, Sep...	29	SINGLE	MALE
6	1090	ADIGUN	ADEBISI	ABIMBOLA	Petros Rd, Off Adeniran...	+2348035700116	Irepodun	Osun	Thursday, Nove...	38	MARRIED	FEMALE
7	1278	OKEDIRAN	OLADOTUN	OLUSOLA	Opp. Blind Centre, Ran...	+2348034466236	Ogbmosho South	Oyo	Monday, Novem...	35	MARRIED	MALE
8	1092	GANIYU	RAFIU	ADESINA	Dept. of Computer Scie...	+2348060596393	Ogbmosho South	Oyo	Wednesday, Dec...	32	MARRIED	MALE
9	1093	OMIDORA	ELIJAH	OLUSAYO	Dept of computer scien...	+2348030712446	Ife East	Osun	Friday, May 23, 1...	42	MARRIED	MALE
10	1095	OMOTOSHO	RUTH	OMOLOLA	Peace and Love Hostel...	+2348060758579	Ijero,	Ekiti	Wednesday, Feb...	25	SINGLE	FEMALE
11	1097	ABDULWAHAB	SARAFADEEN	A.	Stadium Area, Ogbomoso	+2347033673735	Ede South	Osun	Saturday, Februa...	26	SINGLE	MALE
12	1098	OJO	WALE	SAMUEL	AWAU AZEEZ HOSTE...	+2348077532489	Ifelodun	Osun	Sunday, October ...	24	SINGLE	MALE
13	560	GBADAMOSI	GRACE	OLATEMI	Dauri Compound, Pako...	+2348077917669	Iseyin	Oyo	Friday, January 2...	22	SINGLE	FEMALE
14	569	ABDUL	TAWAKALIT	TOYIN	Idi Igba area, Ilora	+2348077788292	Oyo east	Oyo	Friday, November...	22	SINGLE	FEMALE
15	578	BRAIMOH	AKINBISOLA	SAMUEL	Opp Bigun compound, ...	+2348084710779	Ife Central	Osun	Friday, August 17...	21	SINGLE	MALE
16	587	AYUBA	JIMOH	KAYODE	Behind Club 12, Owode...	+2348063922093	Surulere	Oyo	Wednesday, Mar...	22	SINGLE	MALE
17	596	OYEWUNMI	ABOSEDE	OMOLARA	15, Iyalamu, Isale Oyo, ...	+2348081696754	Ifedore	Ondo	Monday, October...	23	SINGLE	FEMALE
18	605	WAHAB	RUKAYAT	AJOKE	Agbekele compound, O...	+2348060939962	Saki West	Oyo	Friday, July 29, 1...	23	SINGLE	FEMALE
19	606	AKERELE	MORENIKEJI	OLUSOLA	GHQ Hostel off Obanak...	+2348085294469	Saki East	Oyo	Tuesday, Decem...	22	SINGLE	FEMALE
20	607	BELLO	KAFAYAT	ABIODUN	Opp Obabi House, Isok...	+2348072696038	Oyo East	Oyo	Monday, March 2...	22	SINGLE	FEMALE
21	608	IDIRIS	LUKMAN	OLADAPO	Opp. Haven of Peace, ...	+2348098571383	Oyo	Oyo	Sunday, October ...	21	SINGLE	MALE
22	609	BAKARE	NOFISAT	OLABISI	Behind BACOTHO, Iso...	+2348080590618	Ori Ire	Oyo	Friday, January 2...	21	SINGLE	FEMALE
23	610	ADIGUN	EDWARD	ADEBANJO	Off Obanako Road, Iso...	+2348086295093	Orelope	Oyo	Thursday, Januar...	20	SINGLE	MALE
24	611	AMBALI	SEMIU	OLUFEMI	Behind Mogbesola Hos...	+2348073067983	Ona Ara	Oyo	Saturday, Decem...	21	SINGLE	MALE
25	612	ADEDIRE	GABRIEL	SUNDAY	Behind Atiba Univ, Idi G...	+2348064626312	Oluyole	Oyo	Sunday, Decemb...	22	SINGLE	MALE
26	613	ADEKOYA	OLUFUNMILAYO	ELZABETH	Behind Satron Grp Schl...	+2348072898186	Olorunsogo	Oyo	Tuesday, Januar...	21	SINGLE	FEMALE
27	631	ONISILE	ADEBAYO	PATRICK	Behind Lalokun 94at, I...	+2348085496714	Ori Ire	Oyo	Saturday, Septe...	21	SINGLE	MALE
28	632	DARAMOLA	JOSEPHINE	ADEOLA	Behind Cocoa house, Is...	+2348098938258	Orelope	Oyo	Sunday, June 24,...	21	SINGLE	FEMALE

Figure 10: View Voters List Menu.

Figure 11: Registered Party Menu of the Application Server.

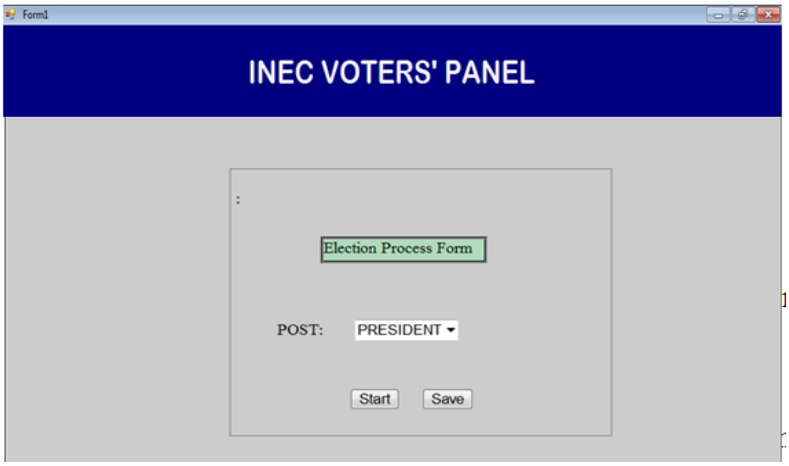


Figure 12: Election Process Menu of the Application Server.

V. Conlusion

The GPS-enabled electronic voting system (GEVS) emerged in this research work as an alternative form of voting method to address the various challenges being faced in an electioneering process. The GEVS was able to tag votes to exact voters and correct poll centres effectively. The GEVS sends feedback to the one hundred and twenty-five (125) users out of one hundred and sixty (160) registered voters on their transactions immediately.

People that were not registered in the database also attempted to vote but were denied access to the database because initially captured fingerprint could not be found for them. The computer systems used as electronic ballot boxes were moved away from the programmed polling centres and we realized that voting could not continue again on such e-ballot boxes because synchronization of the GPS co-ordinates between client and server could not be established. The system could calculate the voting result immediately. This system has provided an efficient way to cast votes, free of fraud, and make the system more trustable, economic and fast.

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