A Distributed Geospatial Information System for Managing Elections: A Case Study of Kenya

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Abstract: ***The integration of GIS, World Wide Web and basic phones to enable easy access to poll information leading to free and fair elections is hardly used and if used, only at the demarcation level. This leads to perceived elections malpractices leading to mistrust and unacceptable results. This research involved development of a prototype that was used to bring all stake holders together in elections through information sharing. It involved customization of the Distributed Geospatial Information System (DGI) to work with basic phones. The prototype was developed using ArcGIS for Desktop in data consolidation and management, ArcGIS for Server in information dissemination, PostgreSQL as a database and Diafaan gateway as an SMS gateway. The prototype enabled an election official or an observer to send elections results or comments that were plotted on the map in form of graphs and pie charts in real-time. The prototype also enabled the citizens at large and other stake holders to send comments or report elections incidences that were also plotted on the map at the respective polling stations. The research found that all mobile phones owned by Kenyans can effectively be used with DGI applications to enable citizen and stake holder's participations. The prototype had shortcomings, especially where some polling stations share the first name. There was need to further develop the prototype to allow addition of constituency name followed by ward name then followed by the polling station name. This will lock a given polling station in the correct constituency. Another way will be to use the polling station code.***

Keywords: Distributed Geographical Information (DGI), Elections, Geographical Information System (GIS), SMS Gateway.

1. Introduction

After negotiation with the British since 1957, the British allowed Kenya to have a voting system that involved one person one say in 1963 elections [1]. Elections in pre-independence Kenya began with polls in May 1963 to decide who would lead Kenya into independence where the Kenya African National Union (KANU), led by Jomo Kenyatta, emerged victorious. An election due in 1968 was postponed till 1969 and was held on a single-party basis after the Kenya People's Union formed in 1966 was banned. Kenya thus became a de facto one-party state and President Kenyatta was re-elected unopposed in 1969 and 1974 [2].

However, under his leadership, competitive elections slowly disappeared as various political parties either joined or were suppressed by the Kenya African National Union (KANU) Moses et al., (2008). This consolidated single-party system would last even after Kenyatta died in 1978 and eventually reaffirmed in an amendment to the constitution in 1982 which made Kenya a one party system. President Moi was elected unopposed in 1979.

Kenya was declared a de jure one party state by the National Assembly in June 1982. President Moi was re-elected unopposed in 1983 and 1988 general elections

On 25 October 2002 President Moi dissolved Parliament, paving the way for Kenya's eighth General Election since independence of all the elections in the Kenyan history, it was only the 2002 elections that all the stake holders and participants agreed that they were free and fair. Kenya was seen as a country with mature democracy being one of the few countries in Africa that can hold free and fair elections. However, this cannot be conclusively ascertained since there was again no citizen and other stake holder's free participation which could have brought out some isolated incidences which were never captured during the elections IREC, (2008).

It did not take too long for the elections management to sharply come into focus. In 2007 general elections, the world attention was turned to Kenya. It took only about 15 minutes on Sunday, after Kenya's president was declared the winner in a deeply controversial election, for the country to explode. Western observers said Kenyan electoral commission ignored undeniable evidence of vote rigging to keep the government in power. Thus one of the most developed, stable nations in Africa, which has a powerhouse economy and a billion-dollar-a-year tourism industry, was plunged into intense uncertainty, losing its sheen as an exemplary democracy and quickly descending into tribal bloodletting.

Easy access to poll information at any one time during the elections circle involving participation of all stake holders leads to confidence in the elections results but that has not been the case [3]. The information could only be accessed to the few and on request. This made the process to meet the standards of a free and fair election not achieved. Furthermore, the elections database had only information on the registered voter. This was not enough as the database should also include population dynamics, the poverty level, the demographics, accessibility and state of roads to the polling.

2. Objectives

- To develop an integrated DGI that can effectively be used at each and every stage in an election cycle to foster free and fair elections.

- To develop a prototype that can integrate basic phones with the DGI during an elections cycle.
- To develop a prototype that can bring together all the stake holders at all the stages in a given election.
- To localize the prototype to the Kenyan case to increase the level of acceptance of the system among the citizens.

3. Methodology

The scope of study covered Kenya. Kenya was divided into 47 counties after the new constitution, it was also delineated into 290 constituencies and 1,450 wards based on the Ligale report that was largely adopted. Kenya now has 33,400 polling centers that were used in the elections. See Figure 1 below. The polling centers are in schools, churches, market places and some are under trees, Independent Elections and Boundaries Commission (IEBC) undertook the mapping of polling stations in 2012 as part of the data was obtained from them the whole country

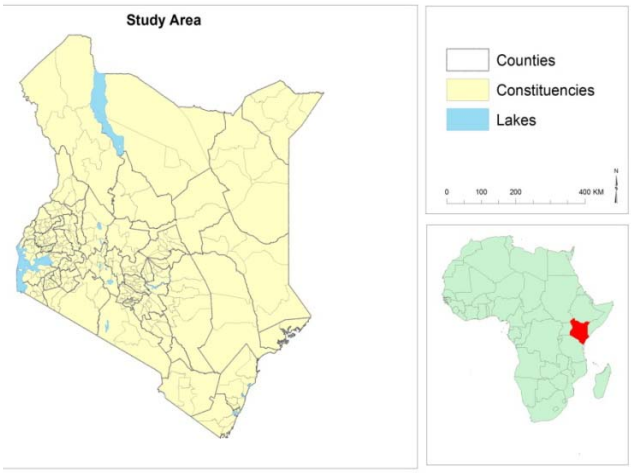

Figure 1: Study Area

The study is a descriptive correlational research designed to rely on both primary and secondary data. Secondary data was obtained from the IEBC and also by carrying out literature review on studies so far done in the same subject. These included Journal articles, Reports, Theses, and other relevant materials. The researcher utilized the administrative data on polling centers, constituencies and counties and population data from data from Kenya National Bureau of Statistics. Dummy data was also used to develop a mock election where returning officers can update some elections results.

3.1 Application Development

The software used in developing of this prototype included; Navicat, SMS gate way, Wamp Sever, PHP, ArcGIS API for JavaScript, ArcGIS for Server 10.1, ArcSDE, ArcGIS for Desktop Advanced (ArcInfo), PostgreSQL Database. The maps were developed in the ArcGIS for Desktop that enable data management, spatial analysis, visualization and development [4] data was consolidated to include the county boundaries, constituencies, wards and polling stations then published to ArcGIS for Server. The spatial data to be published was in PostgreSQL database hence the ArcSDE application was used. ArcSDE technology being a core component of ArcGIS for Server was used to manage spatial data in a Relational Database Management System (RDBMS) that enabled access by ArcGIS clients [4].

Once the data was published in the ArcGIS for Server, ArcGIS API JavaScript was used to develop an application to be used on the client's side that allowed embedding of maps in the Web pages. The JavaScript API was hosted by ESRI on ArcGIS.

The JavaScript code informed the application of which resources it will use to query data as well as display map layers. It also specified what the start message of the application will be and defines a method of ordering which layers are to be queried when re-ordering of layers in the map occurs. Once the application on the client side was developed, there was need to develop a set of common methods used throughout the application, this set of methods includes code to do the following:

- Implement a find task to find constituencies based on a search text provided by the user of an application
- A script to populate a grid based on possible results of the search task implemented above
- A method of reporting results of a particular area via charts based on the attribute data of the area that has been reported
- A method to change the data being queried based on the area chosen by the application user

There was also the need to link basic GSM (Global System for Mobile Communications) [5] phones and the PostgreSQL database for the system to receive and sent SMS's. This called for the use of an SMS gateway. Diafaan SMS Server a trail version for 30 days that uses Windows SMS gateway program for 3G/GSM modems and SMPP SMS providers was usedFor security purposes and to prevent unauthorized SMS's from unauthorized phones, each polling station was tied to a phone No. which was then used to submit the election results. The backend database holding the election information was PostgreSQL.

Each Polling station was assigned a unique ID and the Unique ID is tied to the Ward ID which in turn was tied to the constituency ID and finally to the county ID. When an SMS was sent with a unique ID with results from the various candidates from that polling station, a background after INSERT trigger running in the database executes a PL/SQL procedure which updates the election results entity.
The above elements were hosted on WAMP server that runs on a windows platform, it uses Apache as a web server MySQL as a database and PHP as the scripting language that can manipulate information held in a database and generate web pages dynamically each time content is requested by a browser [6].

Once the election results were plotted on a web map, a PL/MySQL script running on the web server selects data from the PostgreSQL database, converts it into a JSON (a format of representing web data in another) Array and transmits through Hypertext Transfer [7]. A JavaScript function receives this data in JSON format and converts it into a JavaScript array. The data was then translated and populated on the map info windows using ArcGIS

JavaScript API. This occurred in real time; as results are submitted for a certain polling station, the same was pushed on to the map info windows on the elections web map. SMS Transmission was through Safaricom service provider, A GSM modem was mounted on a laptop which had a Diafaan SMS Server Gateway configured to receive and send SMS via the Modem. The SMS server was configured to store and retrieve SMS from the PostgreSQL database. Replies were from queries processed from the DB. SMS were received in the DB with a preset format. A PostgreSQL query extracted results from the text and stored in the DB. When a respective number of the registration clerks are included in the PostgreSQL database and locked to a give polling station, any figures coming in from the clerk in that polling station who has the phone number locked in the database will be updated to the maps and hence accessed by the general public [8].

It was also found that when a returning officers counted results and sent the figures to a given number that was linked to the Diafaan SMS Gateway; the SMS gateway will then push them to the PostgreSQL database. The triggers in the PostgreSQL database will then push the results to the GIS database in form of graphs or pie charts.

It was also possible that during the elections, some events can happen that may require the attention of the elections officials or the knowledge of the public to enhance free and fair elections. This was done mainly whereby the presiding officers send comments emanating from a given polling station, the comments were in form of an SMS and given that that phone was locked to that polling station, the information was plotted on the map with hyperlinks of more information on what is happening. The system assembly is as shown by Figure 2 below.

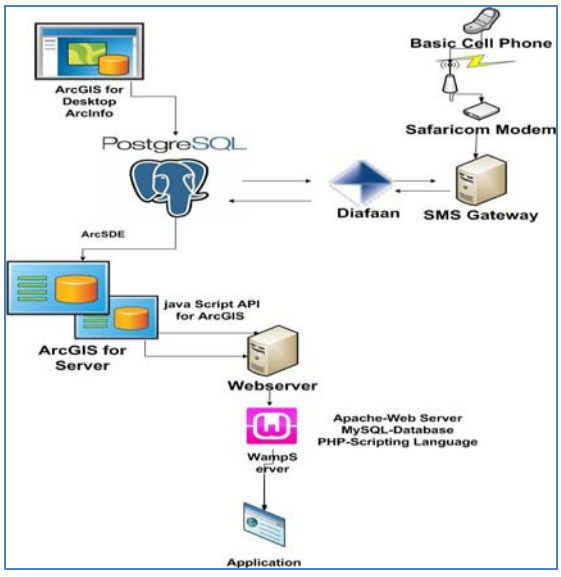

Figure 2: Schematic representation of the prototype

4. Results

- Hosting of the elections maps including polling stations enabled accesses to information by the public and other stake holders via a browser. This provided an effective way of citizens to know the changes in the boundaries and also the location of the new polling stations see Figure 3.
- It was found that all mobile phones irrespective of make were effectively used to send information that was plotted on the map.
- The information sent by the clerk to the database was viewed by the public as well as the politician who in turn can mobilize the prospective voters to register. This information was also accessed by the various stake holders to enable them carry out civic education.
- During the voting exercise, the people who have come to vote will be counted at interval to estimate the voter turnout. The presiding officer will send the figure to the database as voter turnout. The information from PostgreSQL will then be pushed to the GIS database for the elections officers' consumption.
- Once the elections were counted and the party agents confirm with the returning officers that the typed results are the ones that were counted, the results were then sent to the Diafaan SMS gateway that then push them to the PostgreSQL database. The triggers in the PostgreSQL database then pushed to the GIS database to be updated hence being accessed by the public and other elections stake holders.
- The public will also send information on the observations made and the information will be plotted on the map for action to be taken especially if many comments are coming from the same polling station.

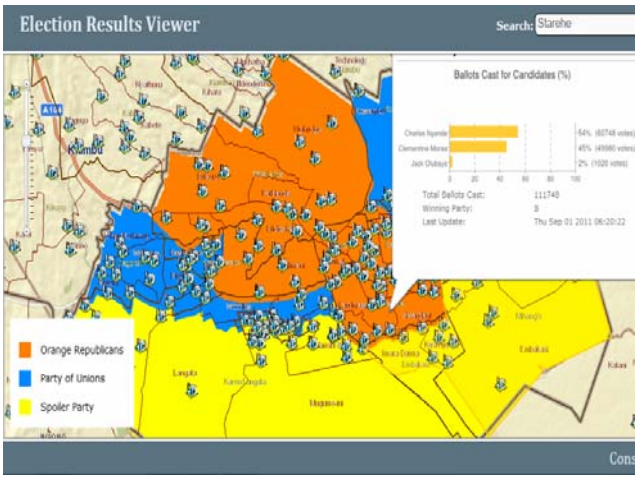

Figure 3: Elections Information

5. Conclusion

The research found that all mobile phones that most of Kenyans have can effectively be used with DGI applications to enable citizen and stake holder's participations. The prototype also demonstrated that the use of GIS in elections can be extended to other areas to cover the whole elections cycle from boundary demarcations to the elections results transmission including results management and citizen participation. It was found that during an elections cycle, the accessibility of information from the boundaries to the location of polling stations with the information on what considerations were put in place to determine the location of the boundary contributed to confidence in the elections.

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