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DEVELOPMENT OF A WEB-BASED SPATIAL CRIME SURVEILLANCE INFORMATION SYSTEM

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ABSTRACT

The computer system has fast become the machine on which almost everyone depends to carry out useful database operations, as well as the storage, retrieval, processing and dissemination of information. A Geographic Information System (GIS) is a computer-based tool that enables the storage, mapping and analysis of spatial data. It uses the statistical analysis offered by maps in its query abilities. Therefore, considering the type of data required for crime surveillance (that is spatial as well as non-spatial in nature); this paper proposes a web-based GIS crime surveillance system. The overall system design is presented using the class diagram of the UML design tool. HTML was used to design and implement the user interface of the system; MySQL was used to implement the back-end of the system; the coding and scripting need was met using Java; and PHP was used to introduce dynamism into the system and handle user's request. Significantly, the system's implementation was successful; since the maps created allowed law enforcement agencies and stakeholders to monitor crime occurrences at real-time. As a result, for prompt decision making, resource allocation for combating crime the system would support its users; and aid the trend of crime to be easily known.

Keywords: *GIS, Information technology, Mapping, Spatial analysis, Unified modelling language*

1. INTRODUCTION

Crime is the breach of rules or laws for which some governing authorities through the legal system can ultimately prescribe a conviction. Crimes are generally considered offenses against the public or the state. They are different from torts which are offenses against private parties that can give rise to a civil cause of action. However, crime rate is tremendously on the increase in Nigeria (Aina, 2007). Many good and innocent Nigerians have lost their lives and properties due to increase in ungodly crimes. The spate of armed robbery is also rife as well as other vices; and the perpetrators often go scot-free. The existence of crime is as old as the creation of man itself, but man has always looked for ways to combat it and reduce it as much as possible. In Nigeria, the case is not different, but with little or no success principally because of lack of what it really takes to curb it. This has become worse, since nowadays a lot of sophistication is needed to handle crime due to the hi-tech dimension it has assumed.

The traditional and age-old system of intelligence and criminal record maintenance do not also suffice and has failed to live up in crime combating, considering existing crime scenarios. Thus, monitoring crimes in different locations without the right equipment have become a huge challenge. For instance, in the Nigerian Police Force the manual system (or paper file) is still used to file almost 90% of information about crime in file cabinets. The forms and books designed during the colonial era are even still in use for data collection. Other Law Enforcement Agencies (LEAs) are not left out. Thus accurate, reliable and comprehensive data round the clock, or trend prediction and adequate decision support is not possible. The solution to this ever-increasing problem lies in the effective use of Information Technology (IT) (Fajemirokun, Adewale, Idowu, Oyewusi and Maiyegun, 2006).

The retrieval of information regarding crime is now possible in any location using IT such as the GIS that allows spatial search. This is because GIS integrates common database operations, such as query and the benefit of statistical analysis using maps. Furthermore, interactive queries; spatial information editing and data analysis; the study of maps; and the presentation of usable results for predictions are possible. Relevant and related hardware, software, and data for capturing, managing, analyzing, and displaying of all forms of geographically referenced information are also easily integrated (Caplan, 2010), using the technology. So, it is easy to interpret and visualize data in many ways that reveal relationships, patterns and trends in the form of maps, globes, reports, and charts. As a result, standard formats like maps are easily manipulated for highly efficient communication to graphically represent, display and share information/data using quasi-intuitive symbolism, and spatial relationships (Ricketts, 1994; Richard, 1999). GIS can be used to organise the different types of data that are used by LEA into an Information system (IS). The police command and other LEAs would find such IS useful to analyse and make decisions. They will be able at the click of a button understand where crime is occurring; where the density of crime is high; and determine the size and type of resources to be deployed in a specific way for crime combating or prevention (Saddler, 1999). The introduction of GIS could thus make the integration of spatial data with that of other law enforcement data possible (Radoff, 1993). The introduction of automated IS for crime mapping and the recording of the time and place; when and where a crime incident took place would enhance the need for rapid response to crime. The proposed system would also eliminate the slow and often prone to error methodology the LEAs in Nigeria are used to. This is because the current system that is used in Nigeria cannot be compared to the ones used by known LEA in other part of the world-wide even in terms of timely and reliable response in information provision.

Therefore, the purpose of this paper is to propose a Web-based surveillance system with GIS capabilities that is capable of providing relevant crime information based on real-time observation. The specific objectives employed in order to satisfy this purpose (as earlier reported) are to: (a) design a spatial crime surveillance system with GIS capabilities; and (b) implement the system in (a). It is hoped that this will sufficiently be used to prevent and combat crime in Nigeria. The system would be capable of assisting law enforcement agents and other stakeholders to use the in-the-field data collection method. With this method staff of LEAs will be able to use Web-enabled devices to upload relevant data without the constraint of location. Thus, even data manipulation, retrieval and visualization of the spatial distribution of crime rate in any local government area in Nigeria at real-time will be possible at the click of a button. Hopefully, this system would also help both the citizens and appropriate government agencies to take steps towards curbing crime in any location. This paper continues with section 2.0 containing a discourse on crime management and other related issues; section 3.0 the methodology; section 4.0 the proposed system design and implementation; and 5.0 the study's conclusion and recommendation.

2. LITERATURE REVIEW

Several surveillance (or observation) systems have been developed and deployed, and researched into. Collins et al. (1999) developed a system for autonomous Video Surveillance and Monitoring; Kleinschmidt (2001) researched into the use of surveillance data for spatial statistical modelling and produced evidence-based maps of malaria prevalence and incidence; Son *et al.* (2006) developed a Forest-Fires Surveillance System (FFSS) that uses Wireless Sensor Networks, middleware and web application; Greenhill and Venkatesh (2006) proposed an alternative and flexible approach to wide area surveillance based on observation streams collected from mobile cameras mounted on buses; Cohen *et al.* (2006 or 2007) proposed an automated surveillance system to monitor video sensors and tag aberrant human activities for immediate review by human monitors; and Fajemirokun et al. (2006), in a related research had described the use of GIS approach to crime mapping and management using data from GPS observations, and additional data from existing digital data files.

These efforts and a lot of others have shown so much promise regarding their deployment. However, the systems cannot support real-time surveillance and monitoring. This is because these surveillance systems use camera, and infrared sensor system and in some cases with a satellite system. Data from them are thus easily negatively affected by poor weather conditions, since there are often limitations due to long scanning period and low resolution of satellites. There is therefore the need to introduce surveillance systems that can automate many of the tasks that currently require the attention of a human operator, through the acts of large-scale video recorders and GIS facilities as proposed in this paper.

2.1. Crime Management

Crimes are human phenomena; and their distribution across any landscape is usually geographically random. As a result, for crimes to occur, offenders and their targets must exist at the same location for a period of time. Several factors (including the lure of potential targets and simple geographic convenience for an offender) influence where people choose to break the law. Therefore, geography plays an important role in law enforcement and criminal justice. Corroborating this is a popular slogan that says "criminals are not spirits"; they move from one place to the other, and live in the society just like every one of us (GIS team, 2005 as reported by Fajemirokun *et al.*, 2006). In this paper, this proposition provided the needed motivation for the introduction of GIS due to its spatial ability for efficient real-time surveillance.

Usually, crime is spatially distributed in patterns; some are discovered while others are not. Factors such as social class, income level, and environmental issues play a part in the type of crimes that are committed. Resources can also influence the probability of the number of crimes committed in any given area too (Katantamalundu, 2004). In the past, law enforcement officers used to sit in their offices waiting for complaints from the public and then react accordingly (O'shea and Nicholls, 2003). However, in the mid 1980s Community Policing (CP) matured and started to attract serious attention. CP emphasizes the analysis of data to examine the nature of complex community problems and evaluate the effectiveness of the efforts made to crime reduction. It calls for information from domains that had previously been neglected and for more complex analysis of that information. Information management, though inherently part of police management, had not really been given the importance it deserved until the advent of CP (O'shea and Nicholls, 2003).

2.2. Geographical Information Systems (GIS) and Crime Mapping

Crime happens in both space and time. Crime can be tied to geographical space which is represented in a map. For a long time maps have been used to show the location where crime occurs, thus making crime mapping an integral part of crime management. Even simple maps are useable in the display of locations where crimes or concentrations of crimes have occurred. Maps are therefore useful in directing patrols to the places where they are most needed. The technique of Mapping could also help to identify crime ridden areas in order to direct resources and ultimately reduce crime and prevent new ones from occurring. It has also been found that maps may have invaluable roles in solving criminal cases (Reno Janet, 1999; Ahmadi, 2003). Furthermore, the traditional crime map is a jumbo representation of an area with pins stuck in it. Though these pin maps are useful for showing where crime occurred, they have limitations. While being updated, the static crime patterns are lost because they cannot be manipulated or queried. Despite these limitations, they are still used today because their large scales allow patterns to be seen over an entire police precinct (boundary of each police establishment from national, regional, local levels) in detail (Canter, 1997).

Additionally, modern GIS software can allow the police to produce more versatile electronic maps by combining their databases of reported crime locations with digitized maps of the areas they serve (Katantamalundu, 2004). By enabling the visualization of subsets of information; digitized mapping could provide an invaluable tool for revealing clusters and patterns of crime that are not readily apparent from a list of crime events in a report. This in turn would support problem-oriented policing efforts by making locations with several calls easily identifiable. Although police forces elsewhere use the GIS technology; the penetration of GIS into every application is still relatively limited worldwide. In Fajemirokun *et al.* (2006) data were obtained from existing digital data files and GPS observations. AutoCAD 2000, ArcView GIS 3.1, Microsoft Excel and dBase IV file served as additional resources employed for the research. However, both the means of data collection and the resources used for the study need review. This is because there are better means of data collection at real time other than the ones used in Fajemirokun *et al.* (2006). This paper differs majorly in that it presents a deployment architecture that can incorporate either the LAN or WAN (theirs were formulated for standalone environment) platforms; an overall design; a GIS development lifecycle methodology; a subsystems in the proposed system architecture; and the layered architecture for the proposed system.

2.3. Conceptual Framework

Currently, most law enforcement agencies use customized software to store, display and in some cases perform analysis on the data (Caplan, 2010). However, many of these applications are difficult to implement and maintain. This is because there are still issues involving compatibility with respect to data, the software, the sharing of data, and the tools across jurisdictive borders. In order to contribute regarding this challenge, it is important to consider the systems that are related to spatio-temporal crime analysis and mapping system. Hence, we consider the four components of the spatio-temporal crime analysis and mapping system, which are: Crime data management; spatial data management; temporal data management; and crime analysis.

The main function of the crime analysis system (or component) is to manipulate spatial and non-spatial data using GIS. This process uses geographic and computer generated maps as an interface for integrating and accessing massive amounts of location based information. The ability to access and process information quickly while displaying it in a spatial and visual medium allows decision makers to allocate resources quickly and more effectively. The crime analysis process is further decomposed into four sub processes: The tactical analysis; the criminal investigative analysis; the strategic analysis; and scientific analysis. The tactical analysis has to do with the use of crime and land use data to locate the crime to be visualized. In the criminal investigative analysis the accused person data and crime data are required. Analyses are then made to find out who commits which crime. In the strategic analysis; crime, socio-demographic, temporal, and land use data are required. But in the scientific analysis, the case is different since it requires crime data to be able to perform useful statistical analysis. This detailed approach to surveillance analysis was not given in earlier works (e.g.

3. METHODOLOGY

In this section the approach and techniques employed to accomplish the purpose of this paper with respect to the specific objectives stated in section 3.0 are presented.

3.1. Data Collection for the Surveillance System

The data required for a GIS based surveillance system to operate are often grouped into spatial and non-spatial (or attribute) data (Fajemirokun *et al.*, 2006). Following (e.g. Fajemirokun *et al.*, 2006; and Idowu, Adagunodo and Esimai, 2012), the operational data for the crime surveillance system will be collected through structured and unstructured personal interview and questionnaire method. This include both in-the-field and out-of-field data entry approach. With the in-the-field data entry approach, local stakeholder's knowledge, their demographic information and home addresses (which can be linked to socio-economic group) meant for on-street non-spatial data filtering will be collected. This will be possible because of the availability of Web-based mobile phones and other digital devices that has ability for location awareness and Web connectivity (Boulos, 2004). Using space-time capturing ability through satellite, participatory mapping will as employed to gather spatial data.

The out-of-field data entry approach will allow data to be collected from accused person's data files. The other type of data that will be so collected are: (i) the particulars of victims of crime and accused person, which are socio-demographic data and will be directly recorded from the people involved; (ii) crime data, the victim of crime data and the accused person data, which will be collected as they are received from police formations. This multiple sources approach of data collection is meant to derive records of meaningful events. This ability to use multiple-sources of data stems from GIS's potential as a powerful resources for many reasons including integrating data from disparate sources to produce new information (Boulos, 2004).

However, to test the implementation of the crime surveillance system, both structured and unstructured interview was carried out with LEAs in the selected test case area. The data that resulted from the encountered were employed to test the system.

3.2. GIS development lifecycle

The system development lifecycle that is also known as the GIS development lifecycle served as the development methodology. It is presented in Figure 1, and discussed as follows. In order to identify the types of data required for crime surveillance: (i) the personal interview methodology was employed, and (ii) the review of literature on existing methods of surveillance systems and crime in Nigeria was done. The web-based GIS spatial crime surveillance system was therefore designed using the Unified modelling language (UML) tool, while the spatial database of the surveillance system was built using MYSQL after the survey of existing spatial databases.

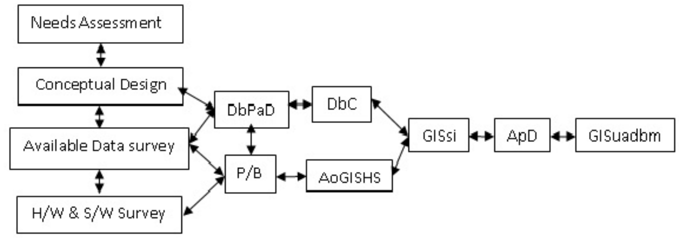

Figure 1: Stages in GIS development lifecycle

As conceptualized in Figure 1, the GIS needs assessment was designed to produce two critical pieces of information: The list, if it is GIS functions that will be needed; and a master list of geographical data. The conceptual design phase of the proposed GIS surveillance system was a primary exercise in the database design, since it is the single most important activity in GIS development. It involved the preparation of a data model. We began with the identification of the needed data and went on to cover several other activities that are collectively termed the data life cycle. In the available data survey stage, a documentation was prepared that was sufficient to evaluate each potential data source for use in the GIS.

Information collected at this stage also formed part of the metadata (data about data) for the resulting GIS database. In the next stage; the survey of available GIS - hardware and software survey was carried out, so that the GIS functionality of each commercial GIS system can be documented for later valuation. This was necessary, since GIS programs will rely on commercially available GIS software. As a result, a survey of the available GIS systems was conducted. The next stage is about the design and planning of the database. In this stage; we developed a logical and physical database design based on the data model; evaluated the potential data sources; estimated the quantity of geographical data; and also estimated the cost of building the GIS database and preparing the data conversion plan. After the preparation of all these plans, the entire cost of the GIS was known and the final feasibility assessment was made. The pilot study and benchmark tests were carried out. In this stage the functionality of the proposed GIS surveillance software was demonstrated. These tests were necessary in order to demonstrate to potentials of the GIS and what it is capable of doing; and the performance data of the GIS system were also determined.

The GIS database construction is also sometimes referred to as database conversion. It is also the process of building the digital database from the source data. This process was included in the overall plan during the previous activity and quality control of the converted data. This brought about the GIS system integration and testing, since all individual components such as hardware, software and data have been acquired. The next stage; the GIS application development phase allowed the putting in place of all the functions needed to create, edit, build, and maintain the GIS database. This was important, since the entire database should be under the control of a database administrator. The use and maintenance phase reminded us of the fact that most GIS databases are very dynamic, and they change almost daily. Therefore the need for daily maintenance was taking seriously. This is one of the rational for choosing the GIS lifecycle model, because it allows for this flexibility. This is obvious as depicted using the double arrows shown in the Figure 1 above.

3.3. System Design

The object oriented approach was used for the system design. This phase included the Graphical user interface (GUI) design using the Hyper-text mark-up language (HTML). The database aspect of this design is not included in this report. This because a GIS database was adopted and used; and its construction was automatic since it involved a database conversion. This is possible since a GIS database is a digital database that is convertible from the source data.

However, the class diagram of the UML was used to capture the required system design. A number of stages were undergone in order to efficiently use the object-oriented design methodology. Each of the stages passed easily for the activities we engaged ourselves with.

These activities were: (a) To understand and define the context and the models of use of the system; (b) to design the system architecture; (c) identify the principal objects in the system; and (d) develop the design model.

3.3.1. System Context and Models of Use

An understanding of the relationships between the system that is being designed and its external environment is important. Therefore, there is need for the required system functionality to work seamlessly with the structure of the system. Contextually, this would enhance the system's effective communication with its environment. The context model of the proposed system was used to capture this, as represented by a subsystem model (designed using the UML package) and presented in Figure 2.

3.3.2. The System Architectural Design

The logical and the deployment architecture served this purpose as follows.

i. The Logical architecture

This architecture describes the system in terms of its conceptual organisation in layers. Each of these layers are subsystems, with each of their purposes explained in the model presented in Figure 3. This Figure is the layered architecture for the proposed system.

ii. The Deployment architecture

The deployment architecture was used to describe the system in terms of allocation of processes to the processing units and the network configuration. The components for this system were selected on the basis of the information gathered. This architecture was introduced to facilitate the selection of suitable hardware and software solutions due to the operational and system needs of the GIS user. In this paper, a centralized GIS architecture was adopted.

The centralized configuration has one central GIS server that supports the GIS files and database transactions as opposed to a distributed GIS server which employs data replication to support a multi-department environment. Figure 4 shows a centralized GIS architecture that includes a central GIS data server supporting GIS activities over a Local area network (LAN) and Wide area network (WAN). It was better to avoid client access to remote files and the database servers over WAN connections. As a result, every possible load increased on the network, which can reduce network performance is avoided. Through a remote terminal as well as a web browser, users can have access to the GIS data server. This is possible since the central GIS server connects to both a web and a map server (see Figure 4). The presence of a centralized data server presents several benefits for the small to medium sized organization. These benefits includes: reduced hardware and administrative costs; improved data access and security; and reduced network traffic.

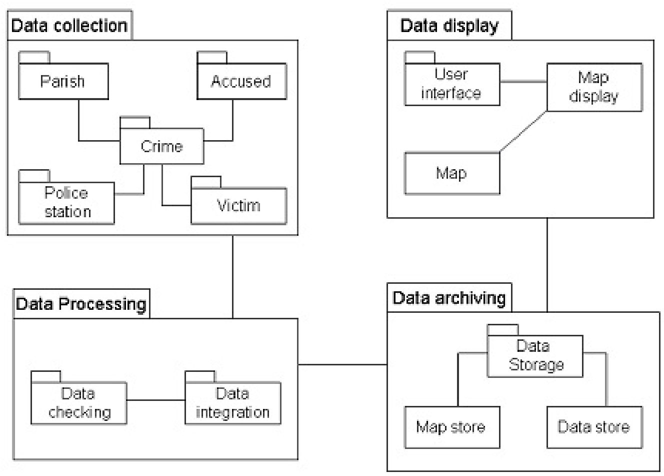

Figure 2: Subsystems in the proposed system

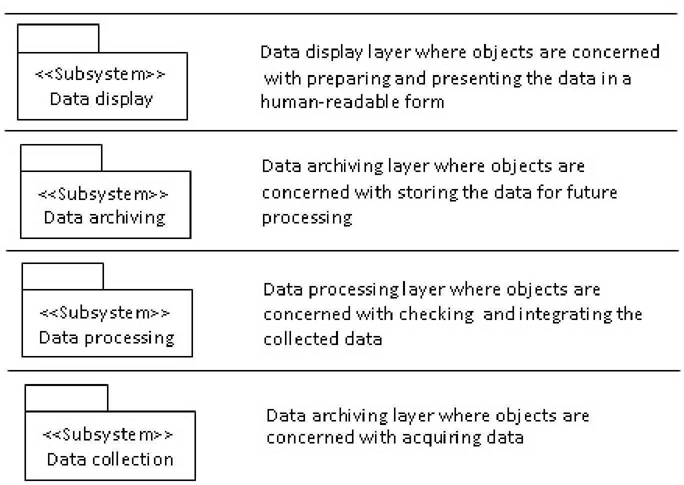

Figure 3: Layered architecture for the proposed system

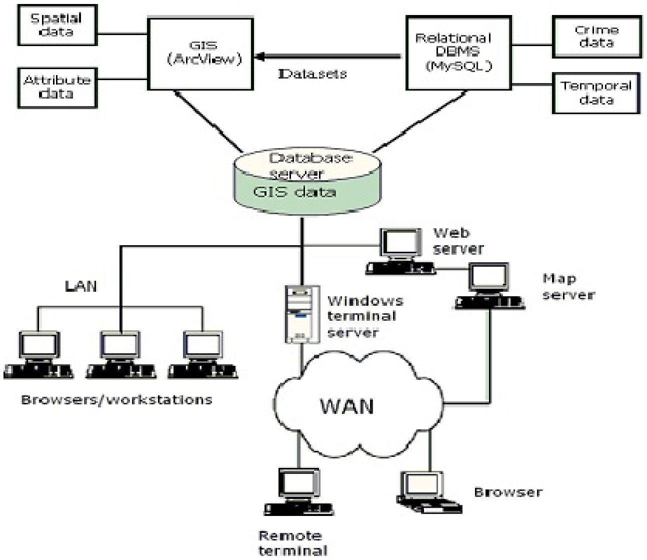

Figure 4: Deployment architecture for the system

3.3.3. *Object Identification*

The object class of the proposed system is presented in this section (see Figure 5). The object classes includes: the Crime, Parish, Station and Person class. The Person class is the generalised class for victim and accused subclasses (see Figure 5). Both the accused and victim class can have relationship with the person class. It is also obvious that a person who might be an accused or a victim could come from a parish. A crime might also occur in a parish or a station (see Figure 5). However, all other possibilities are left to the initiative of adopters of this framework.

3.3.4. *The Design Model*

This design model shows the objects or object classes of the proposed system and the different kinds of relationships between the entities the classes are meant to model. This model serves as the bridge between the requirements for the system and the implementation of the system. The model as an abstraction was intended so that every unnecessary detail would not hide the relationships between the entities and the system requirements. It is also meant to also provide enough details for programmers to make implementation decisions. Furthermore, the design model (see Figure 6) illustrates the software specification for the proposed surveillance system. This includes: The classes, associations and attributes as well as the methods; the attribute type information and navigability.

4. SURVEILLANCE SYSTEM IMPLEMENTATION

The back end of the system was implemented using the MySQL server. It was selected because of its exclusive usefulness in the management of non-spatial elements, such as the crime, accused, victim) and the temporal components. The structured query language (SQL) was used to manipulate MySQL database. The user interface aspect of the system was designed and implemented using the HTML; while PHP was used to provide the scripting language. Specifically, the PHP was used to create web pages and develop the user-interface for the system; and the JavaScript were embedded within the HTML to validate entries into the system. In addition, the rapid development of the required dynamic cross platform database-driven web applications was facilitated and achieved using the PHP/HTML. The purpose of the user interface was to allow maps to be easily viewed. The flexibility and ubiquity of MS Windows was the rational for its use as the development platform. The introduction of PHP/HTML having solved the problem of cross platform, the system could also be implemented on other platforms - UNIX/Linux and others with ease. As a result, the spatial, non-spatial and temporal data can be accessed or analysed through a web browser, thus coordinating effective communication between users and the application itself.

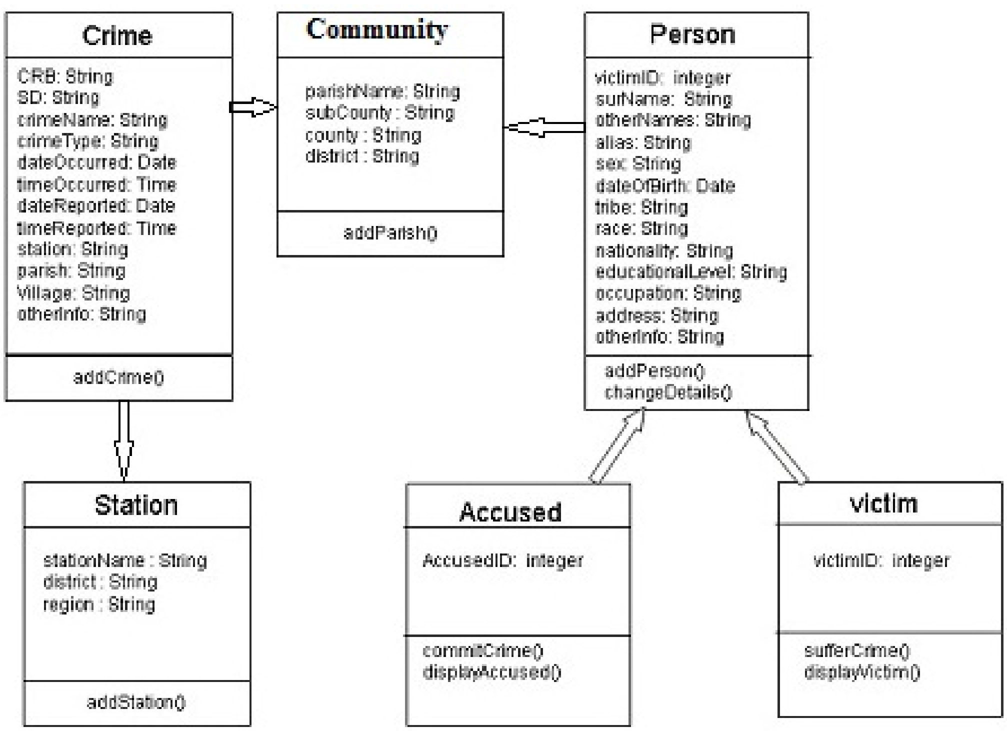

Figure 5: Object classes for the proposed system

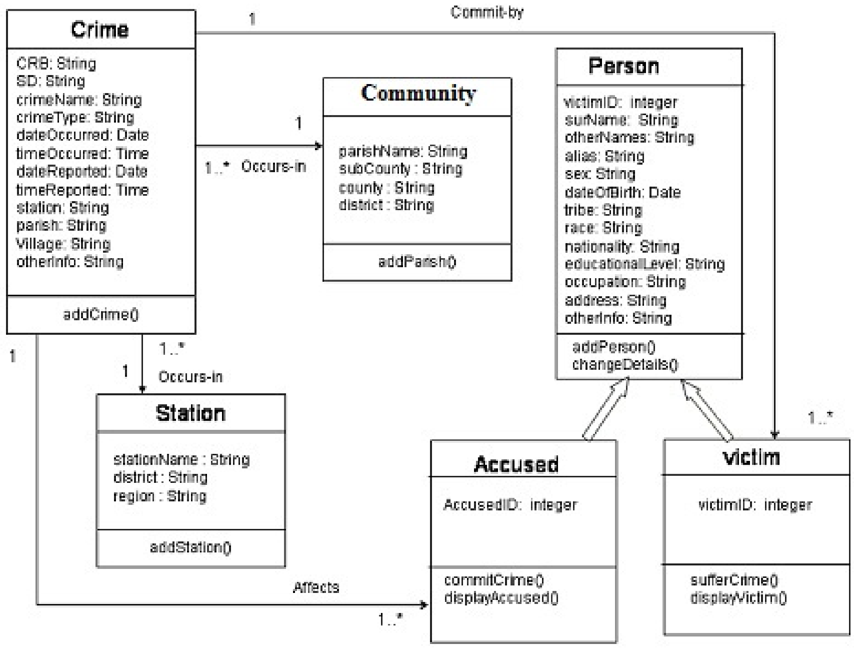

Figure 6: UML design class diagram for the proposed system

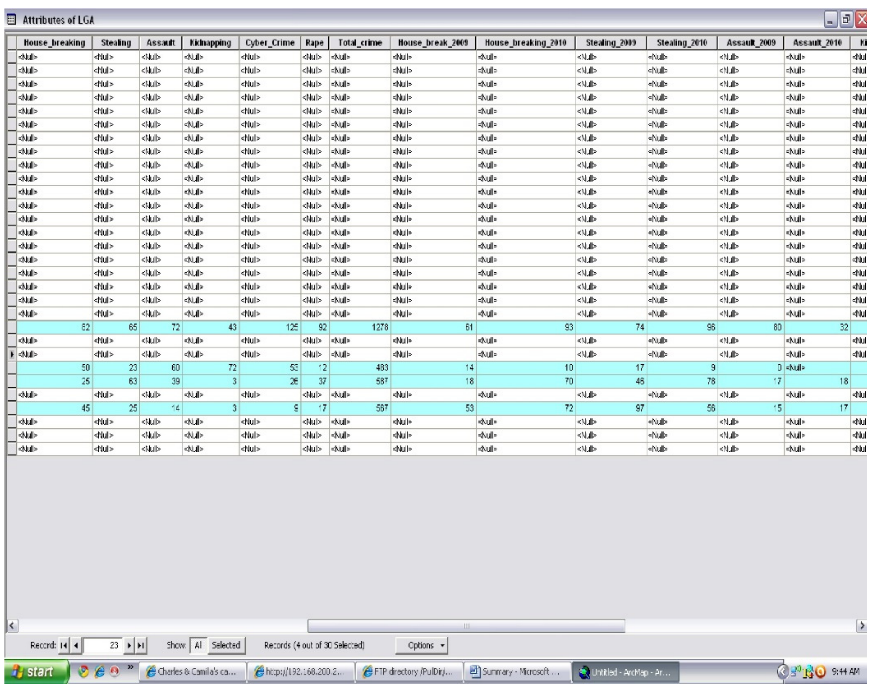
Figure 7: A screenshot of the database

Specifically, the design and implementation of the aspect of the crime mapping system using Osun state as a case study included two design specifications. This implies that there are two parts to this system; the backend GIS and Geo-database and the front end user point. The backend is the part that is responsible for preparing the map and storing attribute information about each of the features on the map. But, the front end user point provides the users with the support of interacting with the web based application. The GIS and Geo-database backend allowed the map preparation using the ArcMap - ArcGIS/ESRI software. In order to represent features on the map, layers were created and different symbols were employed to show the difference between the different layers that are present in the map. As a result, whenever the features are extracted, there would be an attribute table generated at the same time. Additional fields were added to these attribute field in the geo-database. The database design was implemented in ArcGIS - ArcCatalogue software environment. A screenshot of the database created using ArcCcatalogue is presented in Figure 7.

4.1. The web interface front end

In order to make the application web based, the software Mappetizzer for ArcGIS was employed. This software served as an adds-on to ArcGIS. This has to be added to the toolbar of ArcMap on installation. Once this has been done, an already completed map in ArcMap can then be exported as a Scalable vector graphics (SVG) format. The SVG is a family of specifications of the markup language that was used in the crime surveillance system implementation. This file format allows the description of two-dimensional vector graphics; both static/interactive and dynamic/animated. They can be searched, indexed, scripted and, if required, compressed. All major modern web browsers including Internet Explorer 9 beta except the older Microsoft Internet Explorer (IE) support and render SVG markup directly; hence its choice in this study.

The Mappetizzer adds-on was used to test or implement the models of the crime surveillance system presented in this paper. However, due to the cost of purchasing the license of a full version of the adds-on a demo version that was downloaded from the internet free was used. This downloaded version has some limitations that included the DEMO that always appear on the map whenever the system runs. This bottleneck can be overcome by purchasing the full version and the relevant licenses.

4.2. The study's operationalized maps

In this section the maps operationalized or created in ArcGIS Software environment for the purpose of the study reported in this paper are presented.

4.3. The digitized administrative map of the study area

The first map integrated and used for testing the crime surveillance system is the digitized administrative map of Osun state. It was used to show the study areas at a glance. The administrative maps of the study area - Osogbo, Ilesa west, Ilesa east and Ife Central local government areas (see map in Figure 10).

4.4. The Map depicting crime occurrence in the study area

This map was also created in the ArcGIS Software environment. The data the map provided includes the statistical data of crime occurrence in the study area within a-three (3) year period. In order to achieve this in the ArcGIS environment, the base maps (administrative maps) were geo-referenced and a geo- database was then created. This database is relational nature. As a result, each table had a unique identifier for the entry made. The occurrence of the crime incidences were represented using bar charts to show the proportion of crime occurrence within the period under review. The created maps were then visualized in the map layout, thus giving a static view of the geo-database as supported in the background. An SVG macro using a browser provided another means of visualizing the crime occurrence. This created an interactive view with the database on the side view for instant visualization. This paper present the maps showing the proportion of the occurrence of crime in 2008, 2009 and 2010 in Osogbo.

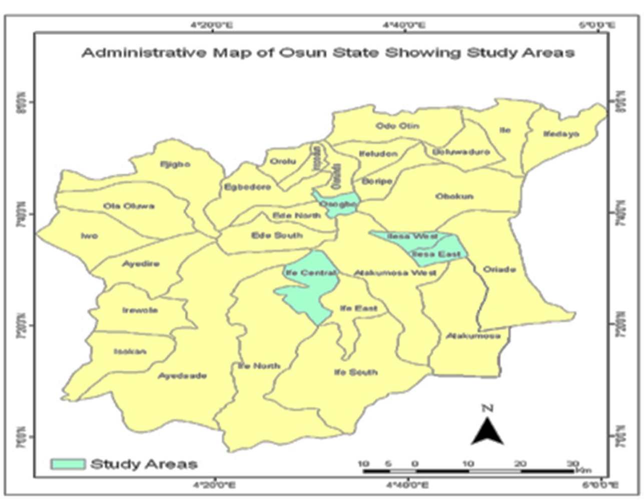

Figure 10: Administrative map of Osun state showing study areas

It also presents that of Ilesa West for 2009, and Ife Central for 2008. These maps are presented in Figures 11, 12, 13, 14, and 15 respectively. These were intended to demonstrate the usability of the models developed and proposed for a Web-based spatial crime surveillance system which is the purpose of the study reported in this paper. More maps could be operationalized and used as may be necessary.

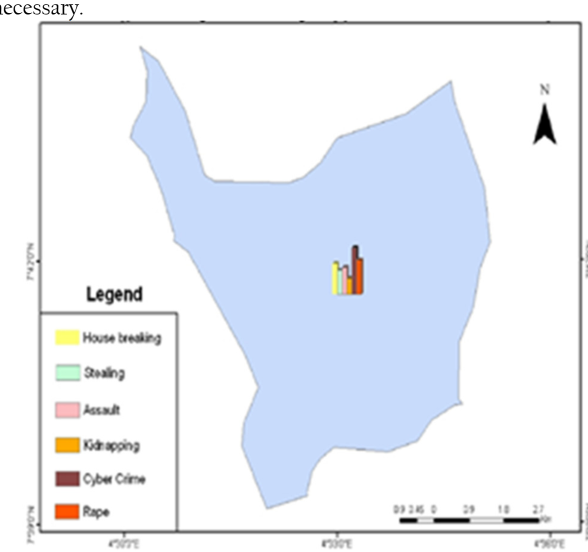

Figure 11: Osogbo map showing the proportion of crime occurrence in 2008

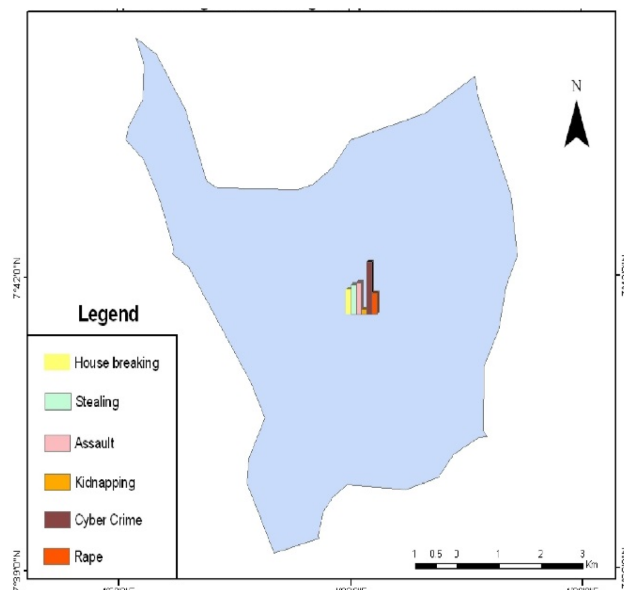

Figure 12: Osogbo map showing the proportion of crime occurrence in 2009

5. CONCLUSION

In this paper, we developed and implemented a Web-based crime surveillance system that monitors crime as well as manage the information/data that accrues in order to report a prospective crime before it occurs. The system allow users - particularly LEA staff to interact with it. There is a database at the backend that can cope with sudden data spike; a deployment architecture that details the way and manner the system would interact with different systems in a WAN, LAN and Web environment. If given the right push and assistance from all relevant authorities, the surveillance system could be used to map and analyze crime occurrences with a view to determining factors leading to crimes and how they can be effectively managed. We, thus argue that an information system that is tied to a map - GIS would help the Nigerian Police Command and other LEAs to easily visualise the location of crime incidents.

Figure 13: Osogbo map showing the proportion of crime occurrence in 2010

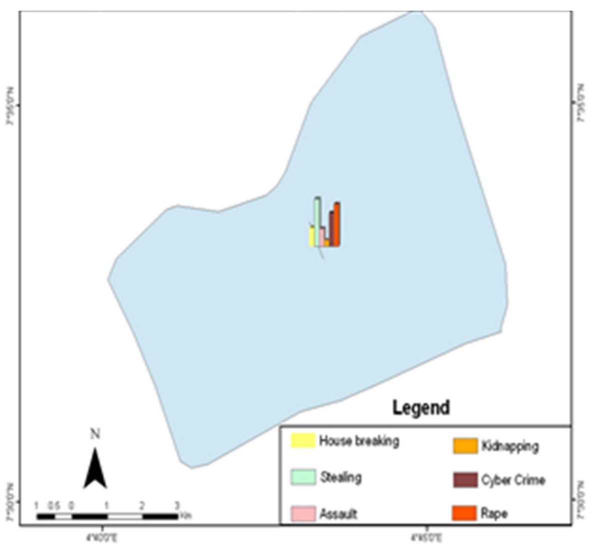

Figure 14: Ilesa West map showing the proportion of crime occurrence in 2009

The premise for this is the ability the GIS provide. It guarantees easy access to and the quick processing of information. It also assures the displaying of information in a spatial and visual medium that would allow its users to allocate the resources needed to combat crime quickly and efficiently. All these are possible since GIS can be used to tie crime data to locations and also aid the easy viewing of crime situations on any specific area on a map. We recommend that GIS Departments should be set up in all Police Stations in order to provide spatial analysis on the fly and at real-time. This would assist in resource allocation for administrative planning. To allow the seamless flow and communication of information between the headquarter offices, the patrol units must be equipped with GPS (at the least) and other GIS related equipment. This should allow their locations to come alive as often as each unit is "polled" or automatically asked to respond so as to enable a two way communication.

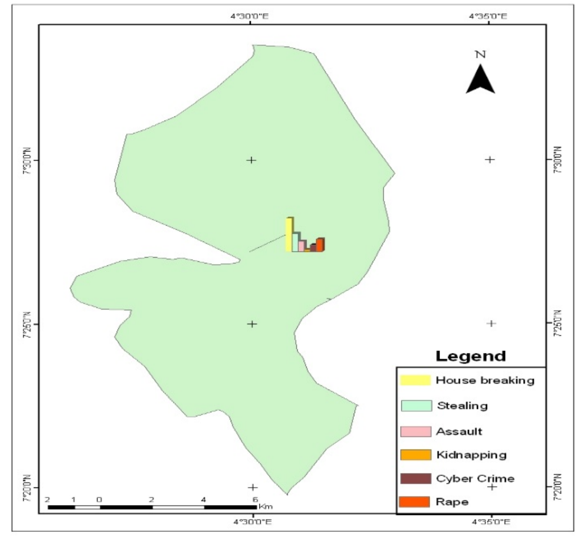

Figure 15: Ife Central map showing the proportion of crime occurrence in 2009

In addition, for future study, rigorous research is needed to be carried out regarding the Web aspect of the system. The purpose is to present a methodology that will allow a more robust integration between the Web and the GIS segment. For instance as earlier stated; only data from personal interview was used to test the system, even though more robust spatial data could be used. At the level of Intranet this could also be tested for data flow. However, the Internet is recommended, and with much support as earlier stated, even Google earth can be incorporated. But, those in Survey, Geo-informatics and other related field must work hard to give Nigeria a befitting digitize map to allow all this play out properly. Thus, with this research, GIS would be usable in tying crime data to crime locations, and also provide useful view of crime situations of the area on a map.

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