International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 12, Number 8 (2019), pp. 1146-1156

A Hybrid Model of a Collaborative Crime Information System

Chikodili Ugwuishiwu[1], Frances Bakpo[2] and Collins Udanor[3]

[1] *Computer Science Department, University of Nigeria, Nsukka, Enugu state, Nigeria.*
ORCID: 0000-0003-3166-6633

[2] *Computer Science Department, University of Nigeria, Nsukka, Enugu state, Nigeria.*

[3] *Computer Science Department, University of Nigeria, Nsukka, Enugu state, Nigeria*

Abstract

High growth in population density is perceived as one of the factors that increases crime incidence rate, making it difficult for Law Enforcement Agencies (LEAs) to enforce law and order in the society. Available information today indicates that the Nigerian LEAs have standalone systems that do not allow them to collaborate for effective crime management. This paper designed and developed a Model of Real-Time Integrated Crime Information System (ICIS) to improve LEA capability on crime management. The model was developed using simple object access protocol and the study adopted quantitative method. The object-oriented analysis and design methodology was adopted in the system analysis using unified modelling language tools. A mobile phone emulator was also designed for crime reporting. PHP, HTML5, CSS, JavaScript, AJAX and Web 2.0 technologies were used to implement the ICIS. A one-time password for security was used as a second level authentication. Queueing network model was applied to evaluate the performance of LEA on crime management. The ICIS implemented enhances productivity of LEAs and increases society's security standard.

Keywords: integrated system, model, crime, Databases and Information system.

1. INTRODUCTION

The prevalent use of information and mobile technologies in our society today has brought about significant improvement in several areas of life, including the security standards of our people. Crime is a threat to the economic, political and social security of a nation and a major factor associated with under development. It discourages both local and foreign investments, affects development and reduces quality of life (Anthony, 2013). Therefore, the prevalence of crime in the world today calls for serious attention, and the degree of crime control and prevention in any society hinges on the efficiency of the operations of Law Enforcement Agencies (LEAs). LEAs have the statutory duties for providing public safety, protect public facilities and infrastructure, maintain order, and protect public officials (Yunus, 2015), (Appel and Abrahamson, 2017), (Bukar, 2006), (Law enforcement, 2017). Security of life, property and welfare of the citizens are the most primary duties of governments and therefore deserves top priority attention (Tafa, 2006), (study.com, 2017). To achieve this aim, technological innovation is needed as a catalyst for tremendous changes in the operations of the police and other criminal justice practitioners in Nigeria (Kent, 2001).

The Nigerian Government has adopted several strategies towards crime prevention and control such as establishment of security and other Law enforcement agencies (Anthony, 2016), (Youth crime watch of Nigeria, 2017). The Government also approved community crime control and prevention strategies such as vigilante groups (Nwaeze, 2010) and yet as a matter of fact, crime is still on a high increase. For any country to fight crime effectively, an integrated system is a necessary tool to enable agencies' collaboration. Integration in this context is the electronic sharing of information by two or more distinct justice entities without regard to time or location (archive.leg.state.mn.us, 2011). Response time, effective arrest, crime prevention and enhanced LEA productivity are the positive effects of an integrated crime information system (lgcnsindia.com, 2003). Studies show that integration has been successfully applied in many areas of life including the education system (ICJIA, 2011), healthcare system (Mavropoulos, et. al., 2017), (Suter, et. al, 2009), banking system (Gaikwad, 2014), (Berger and Smith, 2003), criminal justice system (Holmes et. al, 2001), etc. In developed countries like the USA, and the European countries, etc, integration has been effectively used to improve the activities of criminal justice system. Integration here focuses on sharing crucial electronic crime information to improve public safety (HIJIS Strategic Plan, 2008), quality of information, timely access to a complete and reliable crime information, and enhances the quality of decisions by eliminating error-prone redundant data (Holmes et. al, 2001), (Hunter, 2009). The integrated system also makes information available to non-LEAs with the statutory authority and legal obligation to check crime histories before licensing, weapons purchase, or before being employed in certain sensitive occupations (Darrel, 2016), (ncc.nebraska.gov, 2001).

Studies indicate that the Nigerian LEAs are confronted with a number of challenges that limit their crime fighting potential. These include: absence of integrated systems for collaboration; delay in information dissemination; paper-based crime data capture and lack of functional electronic crime information databases. Therefore, the need to adopt new strategies and innovations to help solve these problems is the motive of this study. Since studies have shown that integrated systems have

helped other countries to control crime, Nigeria with high increase in crime rate needs an integrated system to combat crime effectively. The study aims to design and develop a model of an integrated crime information system (ICIS) to enable LEAs collaborate for effective crime management. The specific objectives were to: design a conceptual model of an ICIS, develop a secured ICIS to enable both the LEAs and the public to collaborate in fighting crime. This work is limited to integrating three agencies which includes the Nigeria Police Force (NPF), National Drug Law Enforcement Agency (NDLEA) and the Nigerian Customs Services (NCS). Queueing network model was applied to evaluate the performance of the LEAs on crime management which was compared with the manual method used by the agencies in determining the average total time taken by each case to be handled (i.e, queueing). This system enables LEAs' integration, crime reporting via mobile phone (using SMS), and instant response to crime scenes. It also enables a higher level authority to query a lower level office when there is delay in handling of crime case for more than two days, for example. The rest of this paper is organised as follows: the remaining part of this section introduces other related works; section 2 shows the methodology containing the framework and model; and section 4 shows the results and discussion.

1.1. Related works

To illustrate different models in practice, this research reviewed some successful integrated systems internationally. The systems reviewed were Colorado Integrated Criminal Justice Information System (CICJIS), Nebraska Criminal Justice Information System (NCJIS), National Crime Information Centre (NCIC), Kentucky Unified Criminal Justice Information System (KUCJIS), and European Criminal Records Information System (ECRIS). The review was based on the technological background of the systems such as the database architecture and other system integration technologies.

In Colorado, the CICJIS adopted a distributed database architecture and used a middleware technology to integrate the information systems of five participating agencies (Kaz, 2006). CICJIS was designed to handle event-driven transfers, queries between systems, and data extracts for decision support and public access Holmes, et. al (2001), ICJIA, (2011). The system takes data entered by the originating agency and automatically updates the systems as a case progresses from one agency to another.

NCIC is a USA central database of criminal justice information and is interlinked with similar systems that each state maintains through a secured network called National Law Enforcement Telecommunications System (NLETS). This system is managed by the FBI, Division of criminal justice information services since 1967 with the aim of facilitating information flow between the criminal justice systems. The system contains two major records which include the personal and property records (NCIC, 2006), (NCIC, 2008).

For Nebraska, the goal of NCJIS is to provide a timely access to secured, complete and accurate information that seamlessly supports the operation of the criminal justice system in Nebraska (ncc.nebraska.gov, 2000). The NCJIS Model utilizes Internet technology to create a virtual warehouse of criminal justice information that is accessible via the state network or through a secured Internet connection. Data files remain under the control and oversight of the participating agencies, meaning that the system model is distributed and uses a middleware technology for data exchange (ncc.state.ne.us, 1997). Similarly, in the Kentucky state, the KUCJIS Model utilizes a hybrid architecture (both centralised and distributed). The system uses middleware for data exchange and a central repository for cross agency information sharing. Kentucky Information and Intelligence Fusion Centre (KIIFC) is the central hub of Kentucky's criminal records management system (RMS) (portal.kstrs.org, 2009). The central repository provides a resource for inquiry/reporting, data analysis and serves as a data backup from where interested agencies can retrieve information (ICJIA, 2011).

As for Europe, the ECRIS uses distributed database technology to achieve an efficient exchange of information on criminal convictions between 27 EU countries (Brussels, 2011). ECRIS uses a common network called Secure Trans-European Services for telematics between Administrations (S-TESTA) to provide an encrypted network. It also uses an interconnection software to allow the exchange of information between Member States' criminal record's databases (ECRIS, 2011), (Nwaeze, 2010). The Central authorities of the Member States control these databases.

A conceptual model was developed to address a number of challenges in modeling Internet of Things (IoT) to support security analysis. This model is based on an architecture-oriented approach that integrates sociotechnical concepts into the security analysis of an IoT system (Mavropoulos et. al, 2017). These reviewed justice systems are generally aimed at sharing of electronic criminal information to avoid redundancy and have timely access to the right information. The crime information flow is from Law Enforcement - Prosecutor – Court - Correction agencies, as the case may be. When a case gets to any agency, the agency handles the case, updates it and forwards it to the next appropriate agency until the end of that particular case in the justice system. The proposed model is a derivative of a model that enables both the public and the LEAs combat crime through instant flow of information and seamless crime information handling.

1.2. The analysis of existing Law Enforcement Agencies system

This section reviews existing system of Nigerian LEAs with a view to highlighting their limitations. To reduce the complexity of the work, only three agencies (Police, NDLEA and Customs) were considered and each of them have existing online web platforms that are basically used to display information about the agency. These three were chosen because they handle the most sensitive crimes common in our society.

1.2.1 Nigeria Police Force (NPF)

The NPF is an agency constitutionally and statutorily charged with the responsibility of preventing and detecting crime, apprehending offenders, preserving law and order, and protecting life and property (portal.kstrs.org, 2009). The existing Nigerian Police website displays information about the

agency such as department, zones, units, area contact, etc. One can equally communicate with them through their social network platform, by phone calls or email. Virtually every other functionalities of the website are not active.

1.2.2 National Drug Law Enforcement Agency

The National Drug Law Enforcement Agency (NDLEA) is charged with eliminating the growing, processing, manufacturing, selling, exporting, and trafficking of hard drugs. The NDLEA's website contains some information about NDLEA without even a functional information repository.

1.2.3 Nigeria Custom services

The Nigeria Customs Service (NCS) is responsible for revenue collection (Import and Excise Duties and Accounting for same), and anti-smuggling activities (Prevention and suppression of smuggling). The Nigerian Customs Service is responsible for clearance of goods and services into Nigeria (Country Dossier Nigeria, 2017). The website displays some information about the agency and most links are not active. There are phone numbers or email addresses one can use to communicate them. The researchers visited these agency's state offices in Enugu state and the findings is that there is no functional data repository at that point in time.

This study shows that these existing Nigerian LEAs' methods of operation were generally manual methods of crime reporting etc., there were no functional electronic databases. Crime data generated were always paper-based and there were serious problems on record keeping, there was no electronic platform for collaboration between the agencies to enable information sharing. There was no electronic monitoring system to check the system efficiency based on how cases are handled in levels (local, state and federal) of a particular agency. The proposed model aims at providing solutions to all the aforementioned lapses in the existing LEAs systems.

3. METHODOLOGY

This section gives analysis on how the system was designed and implemented. It includes the methodology, proposed ICIS and algorithm design.

3.1. Conceptual framework

The first recorded instance of integration of justice information systems occurred in Harris County, Texas, in the late 1970s, when it was decided by local policy makers that individual justice agencies would no longer design, develop and maintain their own systems (Prisoc, 2001). Here all justice agencies were combined on one large system. The Los Angeles system was recorded as the first to use a software called "middleware" to link disparate agency systems into a "virtual" system that pipes information across justice entities to eliminate redundant data entry (Prisoc,2002).

3.1.1. Types of integration

In a country like Nigeria where there is a three-tire administrative system of law enforcement, it is important to understand that the local, state, and federal agencies have to work together to implement the vision of a fully collaborative system successfully since each level has differing perspectives, requirements, and responsibilities. Fig. 1 illustrates the two types of information sharing models, horizontal and vertical (ICJIA, 2011). Horizontal integration extends across a particular level of different agencies while vertical integration extends across the local, state and federal jurisdictions. This paper is based on vertical integration that spreads across the local, state and federal level of any agency.

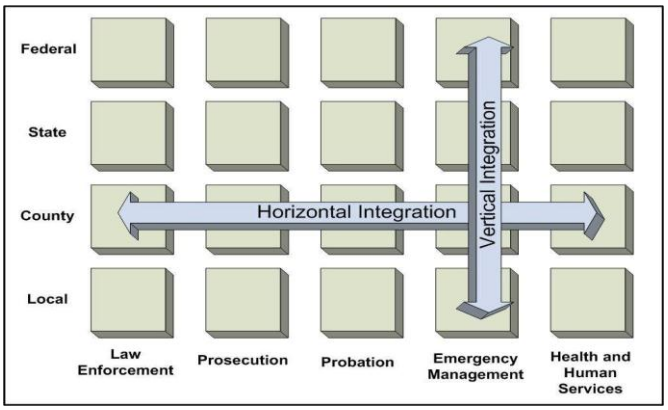

Fig. 1. Information Sharing Model (publications.parliament.uk, 2007-2008)

Integrated System Architecture refers to the underlying structure of systems that facilitate the sharing of information between various LEAs agencies (Newton and Sergey, 2007). An effective integrated system must be designed to accurately capture data entry at its origination point (local level) and facilitate electronic transfer of that information from agency to agency (David, 2004). Classification of integration models include: Anarchy, Network, Centralized, Umbrella, Data warehouse, Distributed, State-wide and Standardized interface models (Newton and Sergey, 2007), (Kaz, 2006). Two of the most popularly used models include the centralised and the distributed models (ICJIA, 2011). The centralized model is designed to allow all LEAs to store their data on one computer as shown in Fig.2. The work (publications.parliament.uk, 2007-2008) emphasised that centralised approach adopted by most early integrated systems is now outmoded due to the availability of technology (middleware) that enables real-time data exchange between disparate systems. The Distributed model enables information sharing amongst autonomous and heterogeneous systems using middleware software to translate information from one system to another. The system was designed to allow agencies to maintain and control their own separate systems which reside on different computing platforms as shown in Fig.3. Based on this background, this paper adopted hybrid architecture (both the centralised and the distributed) to harness the benefits of the two technologies.

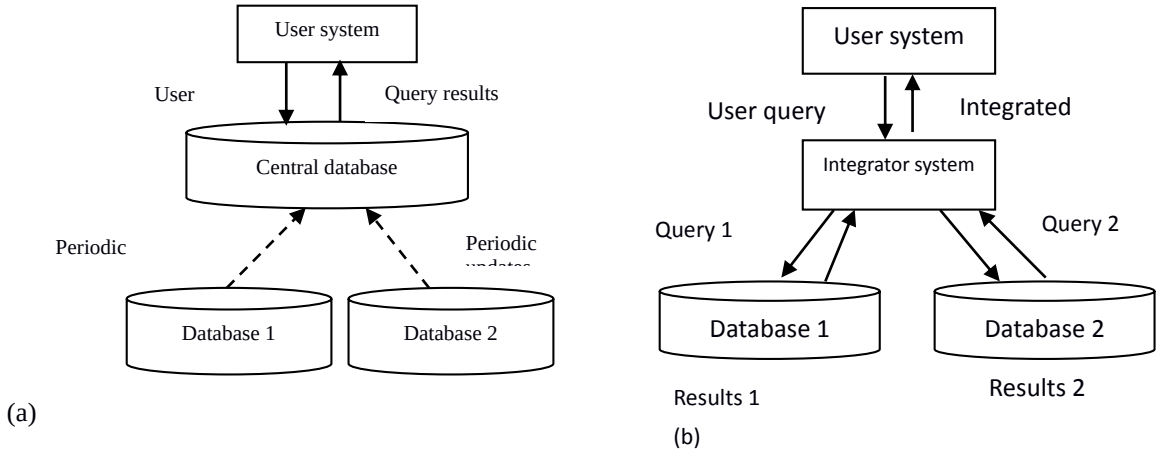

Fig. 2: (a) Architecture of a centralized database [16], (b) Architecture of a distributed database [16]

3.1.2. Integration standard

The International Standards Organization (ISO) defined standard as a document approved by a recognized body that provides for common and repeated use, rules, guidelines, or characteristics for products, processes or services for which compliance is not mandatory. To develop an integrated system, standards should be adopted to facilitate electronic information sharing between disparate LEA systems at all levels (federal, state and local) and is usually developed at national level. Without standards, justice agencies with dissimilar systems cannot easily design or adapt their systems to share data. It should provide agencies with the tools they need to develop systems that can seamlessly share information with partner justice agencies. There is also need for the standard to be regulated for uniformity. Extensible Markup Language (XML) is the most widely accepted standard for data exchange between disparate systems. At present, all major vendors of database software (IBM, Oracle, Microsoft and Sybase) have invested significantly in making their software fully XML compliant (Prisoc, 2003). This work adopted XML data format and simple object access protocol (SOAP) as the communication protocol. While XML is a standard used to encode/transfer data and text between disparate systems, SOAP is a communication protocol that allows programs that run on disparate operating systems to communicate using hypertext transfer protocol and it's XML. SOAP is a communication protocol based on XML (Nwaeze, 2010), (Indika, 2011).

3.2. Research approach

The study adopted the quantitative research method (crime statistics in ICIS databases e.g. number of crimes reported, handled, etc.). The conceptual model was developed using simple object access protocol as a communication protocol. A hybrid of distributed and centralized architectural technologies was used to design the collaborative model for the three agencies (Police, Custom and NDLEA) and a middleware enabled information sharing in the distributed systems. A mobile phone emulator was also designed for reporting crime using Unstructured Supplementary Service Code (USSD) report format. The USSD code follows an interactive format that makes crime reporting easy and user-friendly for the public. Hypertext Transfer Protocol (HTTP) and XML web services were used for data exchange. The researcher visited these agencies' state offices in Enugu state during the analysis stage for information gathering. Sample crime data was collected from Eleme Police Station, Port Harcourt in Rivers State, Southern Nigeria in 2012 and Nsukka Police Station in Enugu State in Eastern Nigeria in 2013 using a data capture form shown in Table 1. This form was designed and given to the Police who filled the form from the crime data they generated through crime report and a data size of 973 cases was collected. Performance of this developed system was evaluated using queuing network model (Ugwuishiwu et. al., 2017) and comparison was made between the existing system and the new system with respect to average response time of the cases (average time needed for an arrived case to be handled). The object-oriented analysis and design methodology was adopted in the analysis using unified modelling language tool. PHP, HTML5, CSS, JavaScript, AJAX and Web 2.0 technologies were used to implement the ICIS. The database contained several tables and was designed using SQLyog and managed by MySQL. A one-time password security token was used as a second level authentication to grant access to the right user. Biometric technology was used for criminal authentication.

Single server (M/M/1) and multiple server (M/M/m) queuing network models were used for evaluating the system performance. Paired sample t-test was used to compare the average response times of cases in each month between the manual system and the developed system at 95% level of significance. The test was done using SPSS version 16.0. MS Excel 2013 edition was used to plot graphs for the performance of LEA on crime handling with respect to time.

Table 1: Data from Eleme Police Station, Port Harcourt(2012), Rivers State

Crime Types	Date of crime report	Time of crime report	Date investigation started	Time investigation started	date investigation ended	time investigation ended	Status
Missing Person	05/01/2013	17:00	05/01/2013	17:33	07/01/2013	10:50	Transferred to state
Pocket Picking	07/01/2013	23:51	08/01/2013	00:53	08/01/2013	19:58	Charged to Court

3.3 The Proposed Integrated Crime Information Model

The proposed system adopted a hybrid of distributed and centralized database architecture as the background architecture and uses middleware software to enable information sharing between the disparate LEAs systems. The distributed database enables individual agency to have full autonomy over her data while central database (all generated data) is used for data analysis and backup. Fig.3 shows the proposed integrated system model. The components of the model include: an informant who reports crime, a mobile phone for crime reporting, an application for directing crime information to the appropriate agency, three agencies (Police, NDLEA, Nigeria Custom Services) with their three levels of authority (local, state and federal), a middleware to enable data exchange among the agencies, individual agency's databases, a centralized database, an Internet connectivity and ↔ bidirectional arrows that indicate the direction of information flow.

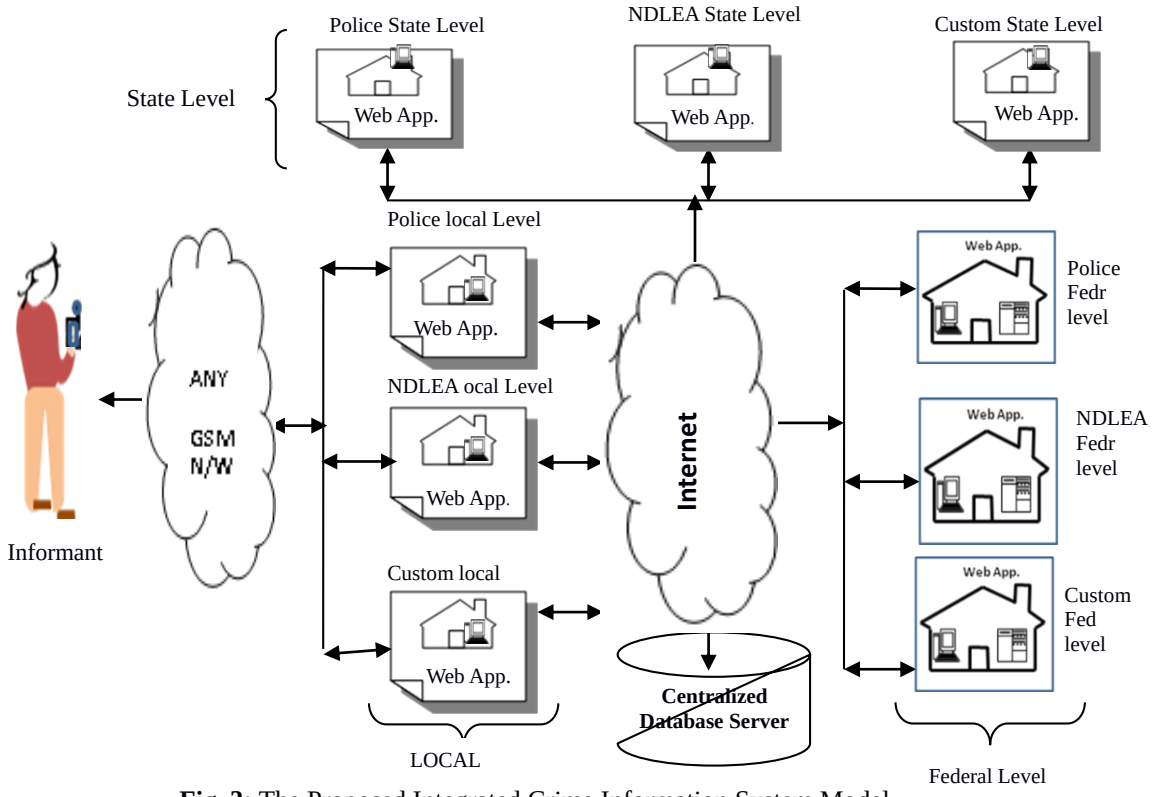

Fig. 3: The Proposed Integrated Crime Information System Model

The operational description of the crime reporting system goes thus: A mobile application developed enables an informant to use a mobile phone to report crime through USSD code in two specific formats as follows: *1112# or *1112*area code#. In the first format (*1112#), the system passes through different screens. The first screen displays list of states as shown in fig.5 (b). The informant selects a state by typing the serial number (SN) of the state. Screen two shows list of local government areas (LGAs) and their area codes (AC) in the selected state. The AC is actually the combination of state and LGA number. For instance, in Nigeria, Abia state is the state with number one, so the code is 01, Aba North is the first LGA in Abia state, therefore, it is number one with AC 01. Now, combine the state and LGA code to get 0101 for Aba North AC in Abia state. Screen three displays list of crime types while the last screen shows a textbox to enter the crime details and finally the informant sends the report. The second format (*1112*AC#) applies when an informant knows the AC of the location s/he is reporting the crime from. Here the informant types both the AC and the USSD code and the system boycotts screens one and

two, respectively (list of states and AC) and goes straight to screen three and four. At the end, a message is sent using the format: *"Phone number *AC*crime type*crime details"*. The middleware interprets this message format and directs it to the appropriate agency based on the type of crime. This software breaks the message into four parts using "*" as the delimiter. The first, second, third, and fourth parts are; the phone number of the sender; the AC, crime type which the system uses to determine which agency to send the message and a short details of the crime incident respectively. Sample messages sent by informants using the phone emulator are shown in Table 2. The mobile application resides on the telecommunication server and when the USSD code is dialled on the phone, the system interprets the code and responds. Because of legal rights and processes involved in obtaining telecommunication short codes in Nigeria, a phone emulator was developed to demonstrate this technology. The phone emulator serves as the informant's phone and the middleware resides in the server where it interprets any request made to it by the phone emulator. When an informant reports any crime to any of these LEAs (local level) through sms, the report is first captured by an android mobile app and this report is made visible to the three levels of that agency. The app identifies the crime type and automatically directs the information to the appropriate agency. For instance, if the crime type is 'car theft'; the application will direct the report to Police etc. The agency at the local level will check if it is within her jurisdiction to handle the case, if so, they handle the case and terminate it or else they forward it to the higher level (state level). The state office can equally forward a case that is beyond her capacity to the federal level. During this process, the information is automatically stored in the agency's database as well as the centralized database. When investigation is completed and the case is prosecuted, the offender's record and the case status are stored in the criminal record repository or updated if it already exists. The criminal record repository enables LEAs or government to know the efficiency of the LEAs on crime management in a specified period of time.

Table 2: Sample informant crime report

Message	***Short Code***
*1413*Car theft* a Toyota car was snatched from Mr. Obi inside UNN campus around 2pm*	*1112*
*1413*robbery*armed robbers are in Mr. Okeke's house now at No 10 Odenigbo road.*	*1112*

3.4. Integrated Crime Information System Algorithm

The pseudo code below shows the sequential steps taken to implement the ICIS model. The algorithm captures all the interactions between all the entities of the system from the crime report to investigation and current status of any case.

1.0 Input crime data
- 1.1 Retrieve area code for reporting crimes if not known
- 1.2 Report crime
- 1.3 Process the crime case
  - 1.3.1 Store the crime information in centralized database
  - 1.3.2 Direct the reported crime case to the appropriate agency
  - 1.3.3 Store the reported crime in the agency's database

2.0 Manage crime data
- 2.1 View reported crime cases
- 2.2 Check if the crime case is genuine
  - 2.2.1 if the crime case is genuine then go to step 2.2.3
  - 2.2.2 else drop the case and stop
  - 2.2.3 start investigation
    - 2.2.3.1 If investigation is delayed beyond 2 days then state queries local agency and end.
    - 2.2.3.2 If investigation finished but case not terminated then forward case to state agency, go to step 2.2.4.
    - 2.2.3.3 Else terminate case and end
  - 2.2.4 State starts investigation
    - 2.2.4.1 If investigation is delayed beyond 2 days then federal queries state agency and end.
    - 2.2.4.2 If investigation finished but case not terminated then forward case to federal agency, go to step 2.2.5.
    - 2.2.4.3 Else terminate case and end
  - 2.2.5 Federal starts investigation
    - 2.2.5.1 If investigation is completed and case not terminated then case forwarded to court.
    - 2.2.5.2 Else terminate case and end

3.0 Crime analysis performed

4.0 End

4. RESULTS AND DISCUSSION

This system enables the LEA to handle crime cases progressively from the point of data capture to the end of the case. A few of the output screen shots are presented below.

Fig 4(a) displays short code an informant dials to retrieve the area codes and reports a crime, fig 4(b) displays a list of all the states in Nigeria. Fig 4(c) shows a typical response of a successful message delivered.

(a) (b) (c)

Fig. 4. (a) Phone emulator – location awareness, (b) list of state and (c) crime report message format screenshot.

This section demonstrates the integration and collaboration aspect of the work. In this application, there is a platform through which an agency can redirect a crime report erroneously sent to it, to the appropriate agency, especially the Police that receives the crime report. This happens when the 'crime direct app' could not find the right keyword peculiar to the specific agency in the crime report message. A page where one agency can search for a criminal information within her agency's database using the criminal's ID is also available in the app. Furthermore, there is also an interface where one agency can search for a criminal's information in the other agencies' databases using the criminal's ID.

Fig. 5 shows a screenshot of a list of delayed crimes. Delay in crime handling is encountered in the system when a reported case has stayed beyond two days in a lower level (local or state as the case may be) without being received (opening the text message) or when the higher level did not receive any report on the status of a particular case within two days of report, for example. When there is delay, the higher level agency's system automatically queries the lower level for reason(s) of delay. This is possible because when a case is reported to a local level (first to capture any criminal complaint), it is made visible to both the state and federal levels of that agency which enables them to monitor the progress of the case.

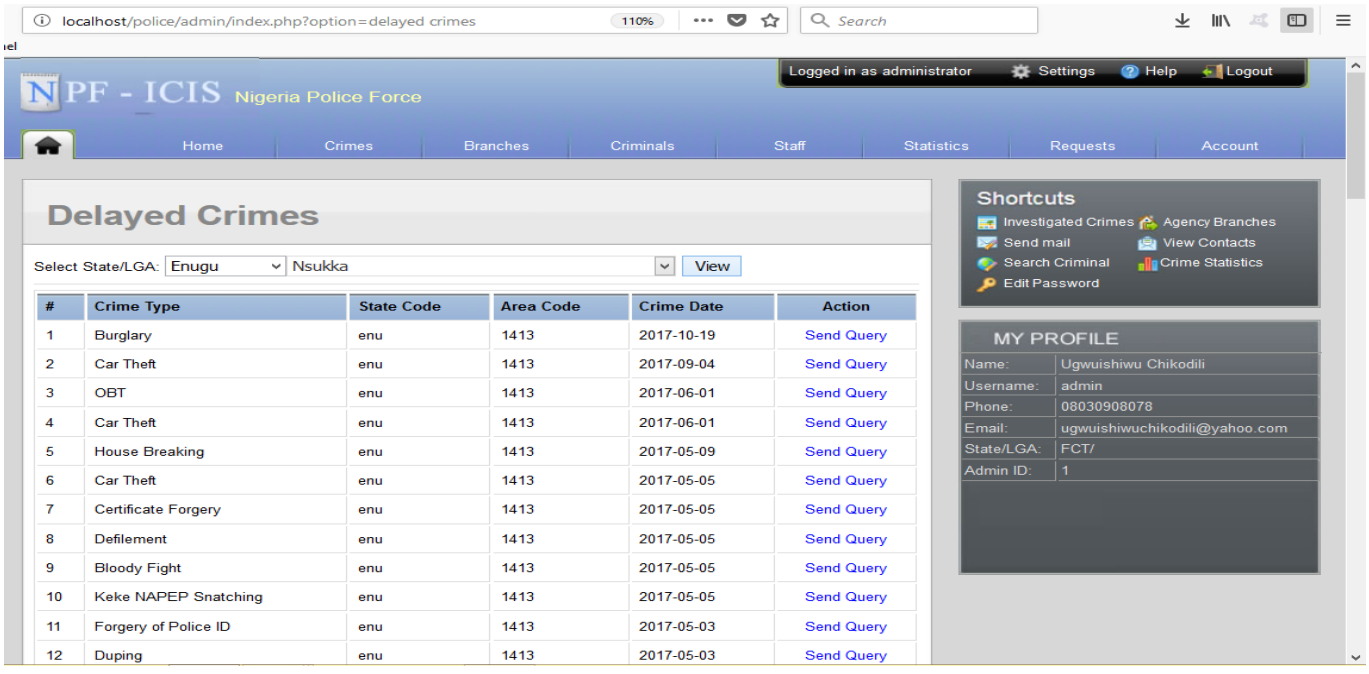

Fig.5. List of delayed crimes

List of convicts (criminal record) in the Police station at any LGA in any state and the status of their cases is also available in the application. When investigation ends and every fact about a case is found, the criminal record shows the status of each case in the repository. The criminal records is sorted in different LGA of every state in Nigeria.

Table 3: Comparison of Queueing Network (QN) Model Results and the Existing LEAs Manual System Based on Response Time of Cases [Ph.d project].

Date	Manual Result based on Ave. Response Time W (days)	Queuing model Result based on Ave. Response Time (day)	The Time difference between the manual and the queuing model result (days)
Jan	5.258872000	2.070971145	3.187901
Feb	7.196345455	3.355670476	3.840675
Mar	4.194486667	2.475347569	1.719139
Apr	5.530294444	2.658706834	2.871588
May	8.481497727	6.137597986	2.3439
Jun	6.137603226	2.821096218	3.316507
Jul	4.744893548	1.872312029	2.872582
Aug	4.518431707	3.534602203	0.98383
Sep	4.874406452	2.071832176	2.802574
Oct	5.926670000	1.711022075	4.215648
Nov	4.785762500	1.616197048	3.169565
Dec	5.201324390	3.478954842	1.72237

Table 3 shows a section of the performance evaluation comparison of queuing network model result and the existing LEAs system based on the average response time of cases, i.e the total time it takes to handle a case. Data used for this evaluations were collected from Nsukka Police in 2013 from Jan to Dec as mentioned in the methodology. These evaluations is at a constant arrival rate of crime cases for a period of one year, 2013. Manual result column is calculated from the method given to the researcher by Police officer during the period of information and data gathering. Queuing model result column is a result from performance evaluation done on the developed ICIS using queuing network model (Ugwuishiwu et. al., 2017). The last column is the difference in the two evaluations (time gained when the new system is adopted).

4.1 Comparison of the Existing System with proposed Systems

In the existing crime information systems (Police, Customs, NDLEA), data are captured manually and there is no integrated system for collaboration between one agency and the other and as well the public. There is no known model to evaluate the performance of the LEAs on crime information management. The proposed system allows the public to report crime cases electronically via SMS to the LEAs and enables agencies' collaboration for a more effective LEAs operations. The new ICIS model was also compared with three other criminal justice information system and was shown on a table format. Queueing network model was used in the performance evaluation. The average response time W (total time a case spent in the system in days) of cases from queuing network model was compared with that of LEAs' manual calculation and the result is shown in Table 5.1. The Comparison of the model results with the LEAs manual system shown in the Table 5.1 for a period of one year showed that the manual system gave the average response times W (days) as 5.258872, 7.19634, 4.1944, 5.5302, 8.4814, 6.1376, 4.7448, for January, February, March, April, May, June and July, respectively; while the ICIS model response time gave 2.0709, 3.3556, 2.4753, 2.6587, 6.1375, 2.8210, 1.8723 for January, February, March, April, May, June and July, respectively. The average response times of cases from the developed model are significant ($p < 0.05$).

The results show that the queuing network model outperforms the manual method at constant arrival rate because of the waiting and service time reduction in crime case handling offered by the developed system.

5. CONCLUSION

ICIS plays a vital role on promoting the security standard of the nation through crime control. However, the existing crime information systems from the Police, Customs, and NDLEA, captured manually lacks integration for collaboration between agencies and as well the public. This paper designed and developed an integrated crime information system using a hybrid of distributed and centralized architectural technology. The paper aimed at providing an integrated system to enable collaboration between agencies, timely access to the right information and electronic criminal information sharing for effective crime management. This hybrid system enabled individual agencies to have control over their data and as well share data in a centralized repository. The developed integrated system enabled the public to report crime cases by sms electronically via mobile devices to the LEAs, allows agency collaboration, crime information sharing and seamless crime case handling for a more effective LEAs operations. A centralized repository was built for the LEAs which contains all crime data generated by the participating agencies. This

resulted to instant flow of information amongst LEAs for immediate action and improved decision making since knowledge is actually based on information (Finelib.com, 2016). This system also helps to avoid unnecessary delay sometimes created by the Law enforcers based on their selfish interest. The biometric technology was able to retrieve the existing criminal's record from the database. The three needs of an information systems are to enable people work faster, better and cheaper (Prisoc, 2001). This paper provided these three outcomes, because use of this system makes information timelier, more accurate and at reduced cost.

Queueing network model was applied to evaluate the performance of LEA on crime management. QN determines the total average time a crime case stays in the system. The average time (days) it takes a crime case to be handled by the LEAs in this application is the main measure of performance of the queueing system. This was compared with the result obtained from LEAs manual calculation and the result was shown. Summarily, the ICIS application transforms LEAs by enabling collaboration, resource sharing, visibility of LEA's operation, timely access to the right information and enhancement on productivity of the LEAs.

It is recommended that the public, government agencies, private and public organizations should use the application to fight crime. Government should also use this application to monitor the efficiency of LEAs with regards to crime management. For example, the database shows statistics of reported crime, investigating or investigated crime, handled or delayed crime, criminal record and how it is managed periodically. Further research should focus on a mathematical model to evaluate the performance of this ICIS and as well apply big data concept in the huge volume of data generated in the database.

REFERENCES

[1] Appel, J., Abrahamson, D.: The Role of State Law Enforcement (2017). [Online]. Available:http://www.safeaccessnow.org/the_role_of_state_law_enforcement (current Dec.2017)

[2] Anthony, I. A.: Social Factors Affecting Effective Crime Prevention and Control in Nigeria. International Journal of Applied Sociology: 3(4), 71-72 (2013). [Online]. Available: http://article.sapub.org/10.5923.j.ijas.20130304.01.html (current Sept. 2016)

[3] Berger, A. N., Smith, D. C.: Global Integration in the Banking Industry. Journal of Banking and Finance, (27), 1 (2003). [Online]. Available: https://www.federalreserve.gov/pubs/bulletin/2003/1103lead.pdf (current Oct 2017)

[4] Bourgeois, D. T.: Information Systems for Business and Beyond (2014). [Online]. Available:https://www.saylor.org/site/textbooks/Information%20Systems%20for%20Business%20and%20Beyond.pdf (Current Sept 2017)

[6] Brussels: Council of the European Union (2010). [Online]. Available: http://register.consilium.europa.eu/pdf/en/10/st15/st15456.en10.pdf (Current March 2013)

[7] Bukar, M.: The Role of Law Enforcement Agencies In The Promotion And Sustainability Of Participatory Democracy And Rule Of Law 1(2006). [Online]. Available: http://mafng.org/symposium1/role_law_enforcement_agencies.pdf (Current Dec. 2017)

[8] Catalogue: The European Criminal Records Information System (ECRIS): state of play and experiences to date in EU Member States (2011). [Online]. Available:http://www.ejtn.net/Catalogue/Catalogue-2011/The-European-Criminal-Records-Information-System-ECRIS-(Current Jan. 2013)

[9] Country Dossier Nigeria: [Online]. Available: http://ec.europa.eu/agriculture/markets/export_refunds/forms/ng.pdf(Current Dec. 2017)

[10] Čudanov, M., Savoiu, G., Jaško, O.: Usage of Technology Enhanced Learning Tools and Organizational Change Perception. Computer Science and Information Systems, 9(1), 285- 302. (2012)

[11] Darrel, F.: Nebraska Commission on Law Enforcement and criminal Justice, 1(2016). [Online]. Available: https://ncc.nebraska.gov/sites/ncc.nebraska.gov/files/doc/OI-15_0.pdf (Current Dec 2013)

[12] David, J. R.:Integration in the Context of Justice Information Systems: A Common Understanding (2004) [Online]. Available: http://www.kms.ijis.org/db/share/public/Pre-RFP%20Toolkit/RW%203-4.pdf (Current July 2013)

[13] Department of Justice: FBI National Crime Information Center (NCIC) (2006). [Online]. Available: https://www.justice.gov/archive/jmd/2008justification/exhibit300/fbi_ncic.pdf (Current March, 2017)

[14] Finelib.com.: Abuja Federal Law Enforcement Agencies (2016). [Online]. Available: https://www.finelib.com/cities/abuja/government/agencies-and-parastatals/law-enforcement (Current Oct 2017)

[15] Gaikwad, P.: Bank Mergers and the Critical Role of Systems Integration (2014). [Online] Available: https://www.cognizant.com/InsightsWhitepapers/bank-mergers-and-the-critical-role-of-systems- integration-codex1000.pdf (Current Oct 2017).

[16] Glossary of Career Education Programs / Legal / Law Enforcement Agent: Law Enforcement Agent: Job Description and Requirements (2017). [Online]. Available: https://study.com/articles/

[17] Law_Enforcement_Agent_Job_Description_and _Requirements.html (Current Dec. 2017). Available at: Law_Enforcement_Agent_Job_Description_and_Requirements.html.

[18] HIJIS Strategic Plan: Hawaii Integrated Justice Information Sharing: Building Enterprise-Wide Information Sharing to Improve Public Safety and Enhance the Efficiency of Operations (2008). [Online]. Available: http://www.search.org/files/pdf/HIJIS-StrategicPlan-Final.pdf (Current July 2013)

[19] Holmes, A., Usery, D., and Robert: Case Study Series, A Report of the National Task Force on Court Automation and Integration, Colorado Integrated Criminal Justice Information System (2001). [Online]. Available: http://www.search.org/files/pdf/Colorado%20case%20study.pdf (Current Oct, 2017)

[20] Hunter, T.: Overview of State Justice Information Sharing Governance Structures (2009). [Online]. Available: https://www.nga.org/files/live/sites/NGA/files/pdf/0907JUSTICEINFOSHARING.PDF (Current Oct 2017)

[21] Illinois Criminal Justice information authority Information (ICJIA): Integrated Justice Models (2011). [Online]. Available: www.icjia.state.il.us/iijis/public/word/TCH2/IJNmodels.doc accessed on 24/04/2013. (Current April 2013).

[22] Indika: Difference between XML and SOAP (2011). [Online]. Available: http://www.differencebetween.com/difference-between-xml-and-vs-soap/(Current Dec. 2017)

[23] Jhurree, V.: Technology integration in education in developing countries: Guidelines to policy makers. International Education Journal, 6(4), 1(2005). [Online]. Available: https://ehlt.flinders.edu.au/education/iej/articles/v6n4/jhurree/paper.pdf (Current Oct. 2017)

[24] Kaz, L.: Modeling and Managing External Interfaces in the Criminal Justice System, 20-23 (2006). [Online]. Available: https://www.ncsc.org/~/media/Files/PDF/Education%20and%20Careers/CEDP%20Papers/2006/LobazaKazCEDPFinal0506.ashx (Current, April 2016)

[25] Kent, R. Use of Information Technology by Law Enforcement (2001). [Online]. Available: www.sas.upenn.edu/jerrylee/programs/fjc/paper_dec01.pdf (Current Dec. 2012)

[26] Law Enforcement Article: What are the responsibilities of a law enforcement officer? pp1 (2012). [Online]. Available: http://www.lawenforcement.com/article/5735937--What-are-the-responsibilities-of-a- law- enforcement-officer/ (Current Dec. 2017)

[27] L.G CNS Police Integrated Information System.: Achieve National Safety by Strengthening the Investigation Capability (2003). [Online]. Available:www.lgcnsindia.com/PDF/industry_01_14.pdf (Current April 2012)

[28] Mathews, S. C., Pronovost, P. J.: The Need for Systems Integration in Health Care. The American Medical Association 305(9), 934-935 (2011). [Online]. Journal of the Available: https://jamanetwork.com/journals/jama/article-abstract/645857?redirect=true(Current Dec. 2017)

[29] Mavropoulos, O., Mouratidis, H., Fish, A., Panaousis, E., Kalloniatis, C.: A Conceptual Model to Support Security Analysis in the Internet of Things. Computer Science and Information Systems, 14(2), 2, 557–578 (2017).

[30] Minnesota Legislative Reference Library: Criminal and Juvenile Justice Information Policy group (2011). [Online]. Available: http://archive.leg.state.mn.us/docs/2011/mandated/110103.pdf. (Current April. 2016)

[31] Mohamed Zain, "Killing Android Mobile SIM Ca rds Using USSD", 2015. Available at http://www.bluekaizen.org/killing-android-mobile-sim-cards-using-ussd/ accessed on 21/03/18

[32] Nascio Recognition Awards Nomination: Award Category, Data Information Knowledge Management, state of Colorado, (2011). [Online]. Available: http://www.nascio.org/awards/nominations2011/2011/2011CO2-Colorado%20Nomination_CICJIS.pdf (Current Dec. 2017)

[33] National Crime Information Center (NCIC): Federal Bureau of Investigation, National Crime Information Center (NCIC) (2008). [Online]. Available: https://fas.org/irp/agency/doj/fbi/is/ncic.htm (Current, April 2012)

[34] Nebraska Strategic Plan: State of Nebraska Criminal Justice Information System, 5-21 (2000). [Online] Available: https://ncc.nebraska.gov/sites/ncc.nebraska.gov/files/doc/cjis-strat- plan-2001.pdf(Current Dec 2017)

[35] Nebraska Strategic Plan: State of Nebraska criminal Justice Information System (1997). Online]. Available:http://www.ncc.state.ne.us/pdf/strategic_plans/cjis/cjis%20strat.pdf(Current March 2013)

[36] Newton H. and Sergey K.: Analysis of Federated and Centralized Information Sharing Architectures (2007). [Online]. Available: http/www.c4ads.org/.../Analysis-of-Federated-and-Centralized-Information-Sharing-Architectures.pdf-Cached (Current July 2013)

[37] Nwaeze, R. I.: Vigilantism and Crime Control in Contemporary Nigeria: A Study of Udenu Local Gov. Area of Enugu State. M.sc. Thesis, university of Nigeria, Nsukka (2010). [Online]. Available: Http://repository.unn.edu.ng:8080/jspui/bitstream/123456789/703/1/richard's%20project.pdf(Current Oct, 2016)

[38] Papazoglou, M. P.:Web Services: Principles& Technology pp1(2008). [Online]. Available: https://www.cs.colorado.edu/~kena/classes/7818/f08/lectures/lecture_3_soap.pdf (Current, Dec 2017)

[39] Police and Detectives, (ND): [Online]. Available:www.bls.gov/oco/ocos160.htm (Current, June 2010)

[40] State of Kansas: Kansas Criminal Justice Information System excitation Environmental Scan. 41(2009). [Online]. Available: https://portal.kstrs.org/traffic%20reports/ecitation/eCite%20. Environmental%20Scan%20v2.pdf (Current Dec 2017).

[41] Prisoc, S.: Integration Architectures: The Range of Possibilities for Justice Information Systems Integration in Illinois (2002). [Online]. Available:

http://www.icjia.state.il.us/iijis/public/pdf/WP/iijis_architecture.pdf (Current July 2013)

[42] Prisoc, S.: Justice Systems Integration: A Definition (2001). [Online]. Available: http://www.icjia.state.il.us/iijis/public/pdf/WP/iijis_defined.pdf (Current April 2016)

[43] Prisoc, S.: Integration Standards (2003). [Online]. Available: http://www.icjia.state.il.us/iijis/public/pdf/WP/iijis_integrationStandards.pdf (Current April, 2016)

[44] Suter, E, Oelke, N. D, Adair, C. E, Armitage, GD. Ten Key Principles for Successful Health Systems Integration. Healthcare quarterly (Toronto, Ont). 13(Spec No), 16-23 (2009).

[45] Tafa, A.: National Summit on Crime and Policing in Nigeria with the Network on Police Reform on Nigeria (Noprin) (2006). [Online]. Available: http://www.noprin.org/index.html APRIL 26-29 (Current March 2013)

[46] The House of Commons London: Thirtieth Report of Session (2007-2008). [Online]. Available: http://www.publications.parliament.uk/pa/cm200708/cmselect/cmeuleg/16-xxvii/16xxvii.pdf (Current, March 2013).

[47] UNISYS: Gwinnett County Criminal Justice Information System Integration Strategic Plan, 2006. [Online]. Available: http://www.gwinnettcounty.com/static/services/CJIS/pdf/CJIS_Strategic_Plan.pdf (Current July 2013)

[48] Youth crime watch of Nigeria.: A program of African centre for citizens Orientation. [Online]. Available: http://www.ycwnigeria.org/security.html (Current Oct. 2017)

[49] Yunus, U. U. S.: Nigeria: The Role of Law Enforcement Agencies in Developing New Mechanism in the Fight Against Corruption (2015). [Online]. Available:. http://allafrica.com/stories/201506300436.html (Current March 2015)

[50] Ugwuishiwu, C. H, Okoronkwo M. C. and Asogwa C. N., "Performance Evaluation of Law Enforcement Agency on Crime Information Management Using QNM" 2017. A Journal published in International Journal of Physical Sciences , Vol. 12(4).

[51] Ugwuishiwu C. H (2018). Development of a Real-Time Integrated Crime Information Model. Ph.D. dissertation, University of Nigeria, Nsukka, Nigeria.