A Model of DNS-Based Bank Credit Risk Management System in Nigeria

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ABSTRACT

This paper presents a model of a digital nervous system (DNS) based on bank credit risk management system (CRMS) in Nigeria. The DNS approach will enable the CRMS to capture credit risk information and provide it where it is needed for decision making and when it is needed. The system also features best tools that can be integrated to the CRMS such as score card system, Global Positioning System (GPS), and biometric-based identification detection, in order to effectively determine creditworthiness of a borrower and quantify banks exposure to credit risk through assessment of credit exposure for each customer and for each credit facility. It has been analyzed and designed with Unified Modeling Language (UML). The system makes possible the ready availability of more comprehensive Credit Risk Management information and this minimizes decision-making errors with respect to loans.

Keywords: DNS, Fraudulent loan, Biometrics, GPS, Data mining, Credit risk

1 INTRODUCTION

Credit risk is simply defined as the potential that a bank borrower or counterparty will fail to meet its obligations in accordance with agreed terms. This is as a result of lack of viable credit risk management system backed with stringent provisions of National Credit Act. Credit risk management deals with identification and mitigation against dangerous situations or risks likely to stand against the ability of someone that has been trusted to borrow money today and pay back tomorrow. The fundamental pillars of bank credit risk management systems are its credit rating system for ranking its customers. Well-managed credit risk rating systems promote bank safety and soundness by facilitating informed decision making. Rating systems measure credit risk and differentiate individual credits and groups of credits by the risk they pose. This allows bank management and examiners to monitor changes and trends in risk levels [1].

IT mainly drives the development in credit risk management as it enables for example, electronic servicing and administration of loans. Thus, reducing transaction costs within the bank and allowing the realization of economies of scale. From a risk management perspective, data-warehousing of credit, loss data, and its accessibility on aggregated portfolio level is crucial. This data is important in analyzing the risk and return of a loan portfolio and sub-portfolios. By offering the possibility to calculate risk measures on portfolio level and run simulations of the loan loss distribution within a reasonable time frame due to highly effective computing power, IT enables the implementation of a risk-adjusted pricing throughout the bank. Risk-adjusted prices can be provided via online applications to the origination units and credit risk management can be transformed into an active risk management approach.

The role of IT in the risk management process is to assist the organization throughout each risk pillar; to support in the obtaining of risk data, to measure risks, communicate the results and to help mitigate operational risk. Measurement of risk will require the gathering of information concerning the current state of the company (comprising financial positions, loss data, and current process flow) as well as external and internal information concerning the likelihood and occurrence of various risk events. Evidence from various researches reveals that Information Technology has contributed immensely in mitigating the problems of Non-performing loan (NPL) for banks that implemented it. IT can be applied to reduce the risk associated with lending due to fraud as well as find an appropriate solution to the borrower’s need for funds, with proper assessment of risk and the inclusion of sufficient control systems to ensure repayment. This can be achieved with the aid of Credit Risk Management System (CRMS). The CRMS adopted by banks in Nigeria has failed in managing credit risk. This research work perceive the failure to be as a result of lack of standard IT-Driven CRMS, prevalence of unethical practices by the management of banks, identity fraud caused by poor system of identification and collateral fraud. Available statistics showed that Credit risk is a major contributor to the distress of the liquidated banks. This is evident in the outcome of banks reformation exercise of 2009, in which eight (8) out of the remaining twenty-five (25) commercial banks were declared distressed by Central Bank of Nigeria (CBN). The bid to address this mishap is the main motivation for embarking on this paper.
The paper therefore proposed a more efficient CRMS for banks using DNS approach on web-based platform. DNS is not a program nor a hardware product, but a combination of IT infrastructures, different software applications. Internet technology and the web concept, which enables the efficient exchange of information on an organizational network [2]. Technological development and business development are inseparable, as technology always answers the needs of businesses and businesses adapt to every technological development, such as the Digital Nervous System (DNS). Modeled on the human nervous system, which coordinates each separate system of the human body, the Digital Nervous System coordinates all the internal and external processes of an organization to easily and swiftly obtain information. DNS also revolutionized the traditional information flow and knowledge sharing between the employees and the company. Through the use of intranets (internal network) or internet, employees can access and easily share information on their own, anytime they need it. Personal computers entered the corporate world and lessened the need for manual paper-based procedures. During the 1970s, large corporations even used Electronic Data Interchange (EDI) as a different approach to send information on networks. Unfortunately, it proved too expensive for small companies and not flexible enough for big companies. Furthermore, it cannot efficiently handle some delicate business activities and transactions. Intranets and extranets have become the modern backbones of effective modern business management and of many e-commerce activities. In the “Digital Era”, they constitute the “Digital Nervous System”. Microsoft is one of the first companies that adopted DNS and greatly benefited from it. A model of the proposed system is presented in Figure 1 below.

**Fig 1: A Simple Model of DNS Bank Credit Risk Management System**

The above model shows how the DNS links various banks and the CBN to the CRMS. It also shows the data required to carry out major processes (Creditworthiness and Credit risk computation) done by the CRMS. The credit risk report generated after the analysis is reviewed by the loan committee who then take the final decision on loan. With this, moral hazards exhibited by loan officers at branch level is avoided since loan officers are tasked with entering borrower’s credit data while the system do risk computation and sends the result to the database for approval decision by loan committee at head office. The decision is sent to loan database which is then assessed by the loan officer. The officer then informs the customer about the decision. The system built on this approach
allows the researcher to provide Nigerian banks greater opportunity to reduce risk, increase productivity and turnaround time and maximize loan quality in higher-risk. It provides a common interface for banks to determine creditworthiness of an obligor, analyze credit risk, monitor loan processes, reduce loan frauds, stop lending with fake collateral, stop multiple lending with same collateral, and promote credit risk assessment that ensures fair credit judgment for all customers. The system will require collaboration with some external system like National Identity Register, Credit Bureau, Land Registration Database and Business Registration Database. Banks should be able access the CRMS via internet. The functionalities that the system will have are listed below:

1. Verify borrowers’ personal, business, credit and collateral details.
2. Detect use of fake identity, fake collateral or same collateral for multiple lending
3. Determine creditworthiness of a borrower.
4. Compute credit risk.
5. Generate loan proposal ready for credit committee review and approval.
6. Monitor non-adherence to loan assessment procedure by any bank and report such occurrences.

The main contribution in this research is the provision of Digital Nervous Solution in controlling Credit Risk Management. The use of DNS approach helps in strengthening the Credit Appraisal Procedures of banks. This is achieved by generating accurate and reliable credit information on bank borrowers from a central database and converting the information to grade using risk assessment parameters.

Other contributions to knowledge in this research are:

1. Integration of biometrics fingerprint and use of GPS system helped in detecting loan fraud by detecting use of fake identity in multiple lending and the use of fake collaterals in obtaining loans.
2. The DNS promotes transparency through information sharing among banks and other credit institution. This helps management of banks and the CBN have first hand information on customer’s global debt profile thereby eliminating erroneous classification of a customer’s loan as performing in one bank and doubtful or lost in another bank.
3. Providing mechanism that heightens borrowers’ incentive to repay, and reducing moral hazard. Every borrower knows that if he defaults his reputation with all other potential lenders is ruined, cutting him off from credit or making it more expensive.

Business Value

The system will reduce the risk of bank failure as well as support wealth creation through lending to customers with high integrity and repayment ability. Promote transparency and reduce moral hazard among bank employees. Help in determining the performance of any bank. It adds value to the CBN initiative to sanitizing banks and contribution to the national development. It also will serve as a proof of concept for feature CRMS endeavor. For example, in the future the system might be extended to include, additional mathematical and theoretical models, such as models of correlation between defaults, where the economy as a whole is examined, and models for pricing corporate assets.

2. RELATED WORK

Author attributed failed loans among commercial banks in Nigeria to lack of a standardized national system of identification, financial mismanagement, operational deficiencies, environmental hostility, relationship mismanagement, and the lack of borrower integrity [3]. Some economic and financial factors have also impeded the development of consumer credit in Nigeria; these include low income, unreliable macroeconomic statistics, high interest rates and weak credit ratings systems for individuals and corporate institutions. Globally, more than 50% of total risk elements in banks and financial institutions are Credit Risk [4]. For some Banks in Nigeria the percentage of Non Performing Loans (NPLs) to total loans was in the range of 50% and represented loans tied to the capital market has lost about 70% of its value [5]. Section 18(1b) of the Banks and Other Financial Institution Act (BOFIA) of 1991, as amended, forbids a bank from granting any advance, loan or credit facility to any person, unless it is authorized in accordance with the rules and regulations of the banks. The section also directs a bank to obtain adequate securities for advances, loans or credit facilities. In addition, section 18(1a) of the Act prohibits a manager or any other officer of a bank from having “personal interest in any advance, loan or credit facility; and if they do, such shall be declared. Available evidence has, however, showed that most of the liquidated banks’ officers flouted these provisions with impunity and some still in operation are allegedly not obeying these provisions [6]. Loans were granted without collateral; when taken, not adequate and when adequate, not perfected. [7] Discussed the values Biometrics, Digital Nervous System, Global Positioning System, Artificial Neural Networks intelligent agent and data mining in mitigating the problems of loan fraud. R. Peter discussed the GPS-based mobile GIS equipment used by Ghanaian surveyors to perform a cadastral survey of the property boundaries as described by the occupant, as well as neighbors [8]. They utilized the latest geospatial technologies to create a land titling process and GIS-based land records system. Credit Assessment Software was
developed by [9] to help bank assess credit risk. The assessment of credit risk by [9] was viewed from the organization perspective. However, this paper that features DNS-based CRMS measures the percentage of each credit facility that will be lost if the customer defaults as well as the expected exposure for each credit facility in the event of a default. Capital computation will ensure that banks make enough provision for the risk. To effectively achieve result the assessment begins with dealing with fraudulent practices such as use of fake identity and fake collateral in accessing loan. It then proceeds to determining creditworthiness of each loan applicant before determining the risk in the loan. It is important to note; that a borrower is creditworthy does not imply that he cannot default. This is because economic factor, natural disaster and unforeseen occurrences can hinder a borrower’s willingness to repay. This is why the system analyzed and designed in this paper is very useful as it pre informs banks on the risk in each lending as well as guides them in taking intelligent decision on loan.

3. METHODOLOGY

This includes the methodology for data gathering and system development. Questionnaire and interview are used to elicit information from credit officers and stakeholders on their perception of bank credit risk management in Nigeria. The use of questionnaire in this study guarantees validity and reliability of responses. Because bank executives are not experts in the work of developing systems, interview is additionally used to enable them express their stories in a language that someone could understand and also to fully describe how they use the system. The researcher investigated the current system and its problems, identifies improvement opportunities, and develops a concept for the new system. The system concept is used as a basis to develop a set of business analysis model that describes how the business will operate if the new system is developed. This is defined in the functional and nonfunctional requirements of the system. The model represents the data and processes necessary to support the underlying business process. Object-Oriented Methodology (OOM) that uses the Rapid Application Development (RAD)- based sequence of Software Development Life Cycle (SDLC) phases is adopted. The primary difference between the traditional approach like structured design (waterfall development, parallel development, phased development, prototyping and throwaway prototyping) and object-oriented approach is how a problem is decomposed.

In traditional approaches, the problem decomposition is either process centric or data-centric. When modeling a real-world system such as CRMS, process and data are so closely related that it is difficult to pick one or the other as the primary focus. Based on this lack of congruence with the real world, the researcher’s choice of Object-Oriented concept was made to balance the emphasis between process and data. The Use Case approach as promoted within Object-Oriented Analysis and Design approach to software development was used in discovering and documenting the functional requirements of the system. This was opted for because it facilitated the users to express their stories of using the system from which the researcher derived the requirements of the system. Unified Modeling Language (UML) is used to come up with the major decision scenarios regarding loan applicants. UML was accepted as the standard language for object development in 1997 [10]. The UML models used in the work are the use case diagram, activity diagram, class diagram and the sequence diagram.

In determining requirements for the new system, Business Process Reengineering (BPR) techniques that involves a substantial amount of change was used against other techniques like Business Process Automation (BPA) that generally involves a small amount of change and Business Process Improvement (BPI) that involves a moderate amount of change. BPR was preferred because it seek to radically improve the nature of the business and also a high-level of business requirements is needed for developing high quality system that satisfy users need. The BPR activity that was adopted is technology analysis. Lists of important and interesting technologies were developed and how each of these technologies could be applied to the business process and how the business will benefit is discussed below. The functionalities that will be provided by the new system will apply the combination of the following technologies:

1. Biometrics based Personal Identification Number
called National Reference Number (NRN) will uniquely identify each customer. The NRN will be assigned by Federal Inland Revenue for every permanent worker and directors of corporate business as a proof of identity. This idea must be backed with strong policies that will (i) stop registration of corporate business whose directors have not got NRN. (ii) mandate directors of already registered business to obtain NRN and update their record with Corporate Affairs commission. (iii) stipulate one NRN per person no matter the number of company he /she has got. This will check or stop using fake collaterals to obtain loan or same collaterals to obtain multiple loans from various banks. (iv) Deny access to loan to individual/directors with no NRN. Fingerprint scanner integrated in the CRMS fake NRN.

2. Global Positioning System (GPS) will be used to read and record the coordinates of landed/ housing collateral obtained by a loan officer or bank approved property valuer. This will also guard against use of fake collateral in obtaining loan. The values read in this exercise will be matched with the existing values in the land Registration database.
3. **Intelligent agents** will provide an effective means for systematic monitoring of loan transactions in the bank, to detect and report to CBN any abnormal financial transactions that may signify a high risk, fraud, and other financial inconsistencies. Such monitoring tasks involve fraud detection, credit risk monitoring, and position risk monitoring. We are confident that intelligent agents are well suited to dealing with the problem of monitoring vast volumes of dynamic information in a distributed fashion. In this way, they are able to detect hidden financial problems, such as financial fraud, handle risks, and other inconsistencies. By utilizing a society of intelligent agents, each charged with carrying out a different function autonomously, credit risk monitoring systems will not only be able to analyze credit risk qualitatively, but will also deduce useful information regarding the state of current investments. There must be one consistent database of knowledge that enables the various agents to exchange knowledge regarding the entities involved.

4. **Data mining technique** will help to distinguish borrowers who repay loans promptly from those who do not. It also helps to predict when the borrower is at default, and in determining the credit worthiness of borrower by analyzing the behavior and reliability of the customers. With data mining techniques, banks can do a thorough profiling and ranking of their branches with respect to loan fraud risk. CBN in the same manner can profile and rank commercial banks. To accomplish this, relevant information can be gathered from the credit risk information service databases. These files contain all the essential information pertaining to a loan. That includes characteristics such as identity of loaner and borrower, location of the branch/bank where the loan was issued and changes that were made to the loan. This data is the cornerstone from which the search for any irregularities in the loan process begins. These are specific sets of instructions the bank personnel must comply with. An example of one such rule is whether a loan has been issued without consultation with the CBN credit guidelines. We need to ascertain if clients have loans at other banks before bank A can confidently issue one. Another rule serves to determine whether the pay back account really belongs to the credit owner.

However, the application will go much further than just data mining. Fraud rule results are converted into risk scores and then displayed by the systems reporting application. The reporting application gathers all the information from the rules and transforms these absolute numbers in percentages and relative scores. This data is then combined to create total risk scores for each branch/bank, countrywide. The higher this score, the more likely irregularities occurred at that specific branch/bank. In addition, the system should have the capability of generating a report or an offer letter after loan approval to a borrower in a clearly tabularized manner on all the interest and charges involved such that from the day one, the customer have a clear knowledge of the repayment plan. It should also generate a report or a Rejection Letter outlining the reasons for rejecting a loan application that did not pass credit check test.

The system will have a dedicated database for all the banks where summarized records of every approved loan will be stored respectively including the expiry date of the facility. It will also keep information on the status of any loan that has expired (whether it has been cleared or turned bad). The system should timely update the CBN bureaus with the information in the form of a credit report; Bank must be mandated to report all liquidated loans to CBN and should be ready to report the status of any unreported loan when such request arises from the CBN. This will deal with the problem of banks not reporting their bad loans to the CBN. Stiff penalty will be awarded to a bank that fails to report a bad loan good to a degree of revoking the license.

4. **ANALYSIS OF THE EXISTING SYSTEM**

At present, there is no CRMS that unifies the loan activities of banks in Nigeria. The current credit assessment system stores client account opening particulars can produce a summary report of the computed financials by credit officers but has no capacity to compute them. It is just a store of client loan information. It lacks capacity to detect fraudulent loans, compute creditworthiness of an obligor, and assess the credit risk and to compute the capital requirements to reduce the credit risk. The decision on loan is either done by credit risk management committee which comprises of the chief executive officers (CEO), and head of credits, or at branch level by either the manager or the loan officer depending on the type of loan. The decisions generated mainly by branch managers or credit officer may be incorrect because of bias which is inherent in human beings and this has resulted into over financing or under financing of businesses thereafter resulting into bad debts. The current system provides reports such as repayment schedules, collateral list agreement and contract forms but does not specify all charges on the loan. In order words there are hidden charges which customers are not aware of at the time of signing the loan contract and acceptance form. The system also has the capacity to monitor repayment and charge default in case of late payment. The bank customer (borrower) applies for a loan by filling out a loan application form which includes information such as personal history, purpose for the loan, amount of loan requested and collateral details. The Loan Processing Flow Diagram of the existing system is shown in Figure 2 below.
1. When the loan request is received by the loan officer, the personal information supplied by the user is analyzed based on the bank Risk Asset Acceptance Criteria (RAAC). RAAC uses PARTS (Purpose, Amount, Repayment source, Tenure and Security) as a metrics; The purpose for the loan must be clear, amount to be granted is determined by the customer’s account turnover and must be within auditors bound. The borrower’s repayment source is the major determinant of lending. The customer’s detail is sent to the CBN CRMS to verify across an existing database if the applicant is indebted to any bank. Approval is granted or rejected based on this information.

2. After certain formalities are fulfilled, a report, in the form of an offer letter, is generated and sent to the user for signing, confirming the approval and acceptance of the loan respectively.

3. If the loan is rejected for some reason, then a report showing the reason for the rejection is generated and a hardcopy is given to the customer.

Limitations of the Existing System

The Limitations of the existing system are summarized below:

1. The information shown on CBN CRMS report is not comprehensive enough in determining repayment ability of a borrower. The system shares customer past indebtedness with other banks and has no other credit information from other financial institution such as PHCN, Tax Office, Water corporation, phone company and so on that a consumer has had a financial relationship with. Banks sometime do not report bad credit to CBN and this encourages fraudulent customers to obtain multiple loans from various banks.

2. Non availability of a technology that unifies loan activities of all banks and promotes credit information sharing among them. This encourages fraudulent customers in using fake collaterals to obtain loan, or same collaterals to obtain multiple loans from various banks

3. The system has not got automated Internal Risk Rating System capable calculating credit risk and computing the capital requirements to reduce the credit risk.

4. Lack of state-of-art tool like biometric fingerprint in identifying customer: Driving license Number or National Identity number is a weak tool for identifying a customer. This is because there is great laxity in a way these numbers are obtained in the country. The institution issuing the identity has no robust database to enable them check for duplication.

5. There is no IT based credit risk management system present in commercial banks that can check on- the- spot customers’ creditworthiness. Banks depend mainly on the information provided by the customer in the application form and have no way of checking for the genuineness of data filled in the form.

5. ANALYSIS OF THE PROPOSED SYSTEM

The simple model of the new system is shown in Figure 1. It presents how the DNS ties each separate financial institution to the Credit Risk Management System. Utilizing a web browser, commercial loan applications from loan officers at various branches of any bank can be analyzed concurrently. An application is checked for completeness before processing. Both the external and CBN credit bureaus are automatically accessed, as well as pre-selected databases such as identity records, business incorporation record for corporate business and collaterals records. All credit reports are processed automatically through a score card, which highlights any deviations from pre-set standards. This is followed by the credit risk computation which include computation of the default risk, risk weighted assets and capital requirement. Basel II Internal Ratings-Based Approach (IRB) is used in credit risk computation. The IRB approach includes three elements (risk components, risk-weight function, and minimum requirements). The components are estimates of risk parameters; probability of default (PD), exposure at default (EAD), loss given default (LGD) and maturity (M) [11]. The results of the analysis on every loan from different banks are sent to the central database. Decision on the loan is done by loan committee of each bank. The result of the decision is sent to the database as well as loan officer’s and manager’s official mailbox. The loan officer credits the customer’s account with the loan amount if approved as well as inform the customer via mail of the transaction. The customer will equally be notified with reasons if the application is unsuccessful. CBN equally uses the system to track any
deviation from loan processing guidelines.

5.1 User Requirements Analysis
Out of the analysis carried out, the following were identified as the user requirements for the system.

Functional Requirements
This relates directly to the process the system must perform or information it needs to contain.

Process oriented:
1. The system must validate bank employee access; only loan officer and loan committee member is allowed access to the system.
2. The system must grant access to CBN credit supervisor to monitor and track any bank that tend to process loan for applicant who already had bad debt with other banks.
3. The system must verify applicant’s identity with the National Identity register.
4. The system must compare coordinates of collaterals measured in the field work with that of property registration database in order to detect fake collaterals. This will aid in tracking if the collateral is currently used to secure another facility in another bank.
5. The system must determine applicant’s creditworthiness and compute credit risk on the loan before approving loan.
6. The system must allow only loan committee to take loan decision loan.

Information oriented:
1. The system must retain information about fraudulent customers.
2. The system should include information on currently running loan.
3. The system must include credit information that is updated at least daily.
4. The system must hold and credit risk information.

Non functional requirements: This refers to the behavioral properties that the system must have, such as performance and usability. They include;

Navigability Requirements
1. The system should allow for easy entry and alert the user of any invalid entry.
2. The system should be able to save and retrieve information.

Operational: this describes the physical and technical environment in which the system will operate.
1. The system should be able to integrate with the existing network of various bank.
2. It should be able to work on any web browser.

Reliability: The system has no availability requirements. The system is to be used during standard working hours (8:30am to 7:00pm)

Performance: This defines the speed, capacity, and reliability of the system.
1. The system should support 100 simultaneous users at all time
2. The system should be efficient, reliable, and should allow timely acquisition of information whenever needed.

Security: This addresses who has authorized access to the system under what circumstances.
1. Only registered loan officers, loan committee, and CBN has authority to manage credit risk with the system.
2. The system includes all available safeguard from viruses, worm, Trojan Horses and hackers.
3. Any user with insufficient fund is automatically disable from accessing the system.

Cultural and Political: This describes cultural, political factors and legal requirement that affects the system.
1. Customers personal and credit information is protected in compliance with the Data Protect Act.
2. Data privacy and security of banks must be enforced by the system.
3. Monetary valued should be in Nigerian currency.

5.2 Use Case and Domain Analysis
Use cases describe in more detail the key elements of the requirements definition. A Use case diagram is used to note the type of users of a system and what each type of user does with that system.
Fig 3: Main Use Case Diagram for CRMS

Actors in the CRMS are:

**Loan Officer** – Bank employee who analyze loan applications. He can also view usage information to know if he has login available and change password his password.

**Loan Committee** – Bank employee who has authority to take decision on loan. He can also view usage information to know the status of their subscription and change password his password.

**Admin** – A CRMS staff that manages users access to the system, change password his password create and updates users account.

**The Supervisor** – A CBN official that monitors banks adherence to the lay down procedure for managing risk. He can also view usage information to know the status of their subscription and change password his password.

**Assess Loan Use Case**
**Primary Actor** : Loan officer
**Supporting Actor(s)**: Billing system.
**Brief Description**: This use case begins when the loan officer logs in to the CRMS and supply his credentials (username, and password) for proper logging into the system. The system verifies the credentials are valid. The system then loads the main menu for the loan officer to assess loan. The system validates information on the loan application and the computes credit risk based on customers credit reports.
Verify Customer Use Case  
**Primary Actor:** Loan officer  
**Brief Description:** This use case begins when the loan officer has successfully logged in. The customer’s fingerprints are read to ascertain his true identity. They system then provides interfaces for the verification of customer information provided in the application form and validates information on the loan application.

Analyze loan Use Case  
**Primary Actor:** Loan officer  
**Brief Description:** This use case begins after loan officer has completed verification of customer information. It provides the capability to compute creditworthiness and determine credit risk.

Billing System Use Case  
**Brief Description:** The use of the CRMS to reduce risk in lending is not free. Banks must make payment for using the system. An initial payment is made by banks to the CRMS account with the bank. The initial payment made depends on the number of login requested by the bank during registration. Deductions are made as the bank uses the system. Subsequent payment amount depends on the number of loans that are analyzed with the system.

5.2.1 Activity Diagram for Credit Risk  
The activity diagram for credit risk assessment is described below.
The figure 5 depicts the following steps:
1. A user initiates credit risk analysis activity.
2. The system displays the creditworthiness form and the user inputs values for the specified parameters and submits.
3. The system computes the creditworthiness and stores the result in the database. The creditworthiness score used in this computation is retrieved from the database.

5.2.2 Sequence Diagram for the CRMS
The sequence diagram is a dynamic model that supports a dynamic view of the evolving system. It shows the explicit sequence of messages that are passed between objects in the defined interaction. It emphasizes the time-based ordering of the activity that takes place among a set of objects, they are helpful for understanding real-time specifications and complex use cases. The sequence diagram helped the researcher to model the dynamic part of the system.
In figure 6, actor and objects that participate in the sequence are placed across the top of the diagram using actor symbols from the use case diagram and rectangles. They participate in a sequence by sending and/or receiving messages.

A line runs vertically below each actor and object to denote the life line of the actors/objects over time. A thin rectangular box, called the execution occurrence, is overlaid onto the lifeline to show when the classes are sending and receiving messages. A message conveys information from one object to another one. The UML diagrams (use case, activity, sequence and class diagrams) have helped the researcher to get a great deal of information about the customer, loan officer and the loan.

**Fig 6: Sequence Diagram for the Credit Risk Management System**

5.2.3 Data Modeling

The CRMS Entity Relationship Diagram is presented in Figure 7 below. The data to support the CRMS can be organized into 15 main categories: customers, banks, loan contracts, current accounts, collateral, assets, customer rating, guarantors, managers, loan officers, loan committee, repayments, repayment types, bills and bills payments. Attributes having asterisks next to them is used to uniquely identify an entity. For example, the customer ID number is used to identify a particular customer. ERD also communicates high-level business rules. Business rules are constraints or guidelines that are followed during the operation of the system; they are rules like a customer can have so many loan contracts.
The new system should support the business rules described below and it should ensure that users do not violate the rules when performing the processes in the system.

**Business Rules**

1. There are several Loan contracts in the system and each customer may have one to many loan contracts. This is communicated by a line on the "crows's foot" nearest the LOAN CONTRACT.
2. A customer can own one or more current account with a bank (communicated by "crows's foot" placed on the line closest to CURRENT ACCOUNT). It is important to note here that having more than one current account does not imply requesting more than one loan at a time.

![Entity Relationship Diagram for Bank Credit Risk Management System](http://www.scientific-journals.org)

3. Since there are several Banks using the CRMS, there are likely to be several loan contracts requested by different customers and processed by different loan officer concurrently. To uniquely identify an individual loan contract:

   I. The LOANCONTRACT entity has added the CUS_customerId as an additional identifier attribute.

   II. The entity BANK has added the LON_loanId as an additional identifier attribute that links a loan to a particular bank.

   III. The entity LOANOFFICER has added the BAN_banksortcode as an additional identifier attribute to track the branch office of the bank of the loan officer in charge.
4. One bill is generated by one or more loan contract (communicated by the two bars on the line closest to BILLS and the “crows’s foot” nearest the LOANCONTRACT).
5. Each bank makes one to several payments depending on the number of loan processed (communicated by the two bars on the line closest to BANKS and the “crows’s foot” nearest the BILLPAYMENTS).
6. A manager supervises one or more loan officer and as well credits customers account. However, only successful applicant account will be credited with the approved amount (communicated by the zero on the “crows’s foot” nearest CURRENTACCOUNT).
7. Each bank appoints LOANCOMITTEE (communicated by the two bars on the line closest to LOANCOMITTEE) and each loan committee can only approve loans given by its Bank.
8. Every customer in the system is associated with one rating.

6. SYSTEM DESIGN

Here, the data that was gathered during the analysis is used to create the blue print for the new system. This is followed by System implementation which focused on building the system, ensuring that it performs as designed.

6.1 Architectural Design

The CRMS adopts a thin Client- Server architecture [12]. The three primary components of a system are client computers, servers and the network that connects them.

The Client will be responsible for the presentation logic that displays information to the users and the acceptance of the user commands (the user interface). It will also contain only minimal (thin) application logic using such programming language as JavaScript.

The Server is responsible for the data storage and data access logic (the database queries is in Structured Query Language (SQL)).

The researcher’s choice of this architecture is because of the following benefits it offers;

1. Scalability: It is easy to increase or decrease the storage and processing capabilities of the servers. If one server becomes over loaded, you simply add another server so that many servers are used to perform the application logic, data access logic, or data storage. This benefit will perfectly suit the volume of customer data and processes done in the CRMS.

2. Manageability: For thin client-server architectures that use internet standards, it is simple to clearly separate the presentation logic, the application logic, and the data access logic to be somewhat independent.

3. Reliability: Because no single server computer supports all the application, the network is generally more reliable. There is no central point of failure that will halt the entire network when it fails, as there is with server-based architecture, only the application requiring that server will fail; the network will continue to function using all the other servers. With this feature, the CRMS is made available to all the banks any time they need it.

However with this architecture, updating the network with a new version of the software is complicated.

The Network: The DNS will link various banks to the CRMS via Extranet VPN or Internet. The system is accessed through passwords, username, and other application-level security mechanisms. VPNs offer secure, reliable connectivity over a shared public network infrastructure such as the Internet, maintaining the same security and management policies as a private network. Thus access is controlled to permit peer connections only within a defined community of interest. The network is already in existence among Nigerian banks and this make the implementation of the new system easy and possible.

6.2 Hardware and Software Specification

The hardware and software specification is a document that describes what hardware and software needed to support the application. Hardware and software specification for the new system are outlined below.

Hardware Requirements

For efficiency especially when handling large volumes of client transactions over the Extranet or Internet, the server on which the software is installed should have; x64-based PC, Intel(R) Core(TM) i3-2310M CPU @ 2.10GHz, 2100 Mhz, 2 Core(s), 4 Logical Processor(s), Physical Memory (RAM) of 4.00GB, total Physical Memory of 3.94GB, Total Virtual Memory of 7.87GB and Hard disk drive of 2.9 Terabytes. The client system is preferred to be always on Broadband and Dual 100 Mbs Ethernet for the web server with of 10 Mbps.

Software Requirements

The system will operate on all common platforms namely Windows, UNIX, Macintosh and Solaris. The system will operate in a Hypertext processor (PHP) environment for the server side; A web browser preferably Internet explorer for client-side and Window, Apache, My-SQL and PHP (WAMP) as web browsers.

6.3 Interface Template Design

For the interface template, the researcher uses two different templates, one for the verification process and another for the rest of other interfaces for the system. For
the verification page, the use of frameset was adopted to divide a browser window into sections called frames. Each frame can display a separate web page. A Fixed left frameset was used. The left frame contains navigational elements, and the main frame that displays the verification site content. The researcher’s choice of using frameset is because of the numerous advantages it offers and because verification process has numerous activities which include, collateral and business registration verification as well as credit bureau record check. All these processes are achieved in one page. This helps in improving site performance, providing separate scrollbars for each frame, and simplifies site performance.

For other interfaces, the researcher decided on a simple, clear design that had a modern background pattern, with the CRMS banner on the top, the copyright statement on the bottom page, and the left edge for the CRMS animation. Main menu follows immediately after banner for navigation within the CRMS. The menu contained the links to the four top-level screens (interfaces 1, 2, 4, and 5). The interface 3, is part of the home page screen therefore, the user can quickly enter his/her login details to log in to the. The center area of the screen is used to present the main page (Home page) for a particular level of user. This page contains links (navigational system) to all activities for the user. It is also used for displaying forms and reports when the appropriate link is clicked.

### 6.4 Input Design

This design includes both the design of input screens and all preprinted forms that are used to collect data before it is entered into the CRMS. The type of inputs used in this design are text fields, number fields, and drop-down list boxes.

**User Interface Forms**

The user interface forms were designed using Hypertext Preprocessor (PHP). Different screens were developed. Credit risk input form is one of the forms designed and is shown in Appendix A

**Credit Risk Input Form**

The form provides the loan officer the column for entering the customer’s unique identity as well as his branch code. When he clicks on the retrieve button, the system retrieves part of the customer’s records and his creditworthiness score from the database. These retrieved data are read only and so prevents the loan officer from manipulating the data. The loan officer then fills in the remaining fields and clicks on the compute credit risk button to compute the customer’s credit risk.

### 6.5 Input Validation

This was achieved using Javascript & PHP script. All data entered into the system are validated to ensure accuracy. The system does not accept data that fail any important validation check to prevent invalid information from entering the system. The system identifies invalid data and notify the user as shown in Appendix A. The validation checks used are completeness check, format check, consistency check and database check. Completeness check ensures all required data have been entered. Format check ensures data are for the right type (e.g numeric, e-mail) and in the right format (e.g. month, day, year). Consistency check ensures combinations of data are valid, (e.g. in the case of new password and confirm password). Database check compare data against a data-base to ensure they are correct. This is specifically used to ensure that banks do transactions concerning their bank alone. The user’s username, password, and SOL are compared against a database and transactions concerning them are retrieved.

### 6.6 Output Design

The goal of output design is to present information to users so they can accurately understand it with the least effort. Outputs in the CRMS are the reports the system produces. The outputs in the CRMS are on screens, paper, and mobile phone. The types of reports include, detail reports, summary report, and exception report. Sample outputs for the CRMS are shown in Appendix B.

### 6.7 Interface Evaluation

Interface evaluation was done while the system is being designed so that any major design problems can be identified and corrected before time. An interactive evaluation was conducted by the researcher and the potential users. As the user interacts with the prototype, the researcher records the situation when the user appears to be unsure what to do, make mistakes, or misinterprets the meaning of an interface component. Several minor changes were identified and modifications were made to user’s satisfaction.

### 6.8 Program Specification

Program speciation provides more detailed instructions to the programmer about how to code the modules. This is shown in Figure 8.
**Program Specification 1.1.3 for Credit Risk Management System**

**Module**

Name: Credit Risk Computation  
Purpose: Credit Risk Computation  
Programmer: Ajah Ifeyinwa  
Date due: ____________

**Events**

Name: Credit Risk Computation  
Purpose: Credit Risk Computation  
Programmer: Ajah Ifeyinwa  
Date due: ____________

**Input Name**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Provided by</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRN</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.3</td>
<td>Used to identify customer</td>
</tr>
<tr>
<td>customer_name</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.2</td>
<td>Used to capture customer's name</td>
</tr>
<tr>
<td>bank</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.2</td>
<td>Used to identify customer’s bank</td>
</tr>
<tr>
<td>SOL</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.2</td>
<td>Used to identify customer’s branch</td>
</tr>
<tr>
<td>loan_type</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.3</td>
<td>Used to capture the type of loan requested</td>
</tr>
<tr>
<td>PD</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.2</td>
<td>Used for credit risk computation</td>
</tr>
<tr>
<td>exposure</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.3</td>
<td>Used for credit risk computation</td>
</tr>
<tr>
<td>collateral_value</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.3</td>
<td>Used for credit risk computation</td>
</tr>
<tr>
<td>guarantee_amount</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.3</td>
<td>Used for credit risk computation</td>
</tr>
</tbody>
</table>

**Output Name**

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Used by</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>refnum</td>
<td>INTEGER</td>
<td>Program 1.4</td>
<td>Loan contract reference number</td>
</tr>
<tr>
<td>NRN</td>
<td>VARCHAR (45)</td>
<td>Program 1.4</td>
<td>Customer’s biometric based identity number</td>
</tr>
<tr>
<td>customer_name</td>
<td>VARCHAR (45)</td>
<td>Program 1.4</td>
<td>Customer’s name</td>
</tr>
<tr>
<td>Loan_amount</td>
<td>VARCHAR (45)</td>
<td>Program 1.4</td>
<td>Approved Loan amount</td>
</tr>
<tr>
<td>PD</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.3</td>
<td>Probability of Default</td>
</tr>
<tr>
<td>EAD</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.3</td>
<td>Exposure At Default</td>
</tr>
<tr>
<td>LGD</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.3</td>
<td>Loss Given Default</td>
</tr>
<tr>
<td>EL</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.3</td>
<td>Expected Loss</td>
</tr>
<tr>
<td>RWA</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.3</td>
<td>Risk Weighted Asset</td>
</tr>
<tr>
<td>Capital</td>
<td>VARCHAR (45)</td>
<td>Program 1.1.3</td>
<td>Capital required to safeguard credit risk</td>
</tr>
</tbody>
</table>

**Pseudocode**

**(Credit-risk competition module)**

- Enter customers NRN & SOL
- Retrieve creditworthiness details from creditworthiness table
- IF no NRN and matching SOL is found
  - Set not found True
  - ELSE  SET Not Found False
- Enter values for loan type, exposure, collateral value and guaranteed amount
- Compute credit risk Save result in credit risk credit table
- End-if
- Return

**Business Rule:** If a customer’s creditworthiness score is not found, the user will be informed. “The system will redirect the user to do creditworthiness computation for the customer.”
Credit Risk Computation Design

The visual representation of conceptual classes or real situation objects in this domain adopted [9] and is figured out in Figure 9. The credit risk computation class uses the customer class and creditworthiness class to gather the customer data and the creditworthiness rating. It then processes the data about the customers and computes the credit risk for all the applicants. The IRB approach of Basel II [11] is adopted in computing credit risk. The IRB approach includes three elements (risk components, risk-weight function, and minimum requirements). The components are estimates of risk parameters: PD: probability of default, EAD: exposure at default, LGD: loss given default and M: maturity. Instead of using a lookup table based on external ratings, the internal ratings-based approaches (IRB) use a function. The risk-weight assets (RWA) are a function of exposure at default (EAD), loss given default (LGD), probability of default (PD) and maturity (M), where (K) is the capital requirement and is given by:

\[
RWA_{\text{IRB approach}} = 12.5 \times EAD \times K
\]

\[
K = LGD \times f(PD) \times f(M,b)
\]

The following domain classes have been identified for the Credit Risk Computation.

Data Store: This class is a pool of many classes as their attributes flow into this. The main classes that flow into this are customer, creditworthiness, collateral and guarantee.

1. Customer: The customer details will be stored in the database. It includes a unique id for every customer; the brand of the bank of the customer will also be saved in the database. The industry type like infrastructure, commercial real estate etc will also be stored in the customer table of the database.

2. Creditworthiness: The creditworthiness class consists of creditworthiness reference number, the unique id of the customer, rating, date of loan etc. The creditworthiness reference number is unique for every loan taken by the customer. The customer id is unique only for the customers. All the data should be stored in the database.

3. Collateral: The customer may give collateral like cash deposit, gold, land or housing collateral etc. After performing all the haircuts the value of the collateral should be stored in the database. It is not the actual value but the realizable value of the collateral should be stored in the database.

4. Guarantee: Every applicant has a guarantor that may extend guarantee to him/her. In case of the default the sum assured will be paid by the guarantors. So in such a
case the guaranteed amount should also be stored in the database.

**Data Manipulator**
The data manipulator helps in manipulating the data in an efficient and significant manner. The manipulator plays a significant role in connecting both the above group of classes i.e. it manipulates the data that is displayed on the GUI and directs it to the data store pool after the completion of the validation process. The groups of classes that flow into the data manipulator are Default risk computation, RWA computation, Capital computation and Report.

1. **Default Risk Computation:**
The expected loss for each applicant for all the advances will be calculated by this class. The result of this calculation is used in calculating RWA and is stored in the database.

2. **RWA Computation:**
The risk weighted assets for all the advances will be calculated by this class. The risk weights and credit conversion factor value will be checked from the above classes and finally the risk weighted assets will be determined in the RWA computation. It is also stored in the database for future references.

3. **Capital Computation:**
The capital computation is the class which computes and the capital required to reduce it. This calculation is also performed from the data computed by the RWA computation class.

4. **Report:**

   This class retrieves the result of the credit risk computation from the database. Loan decision is taken by the loan committee based on this report. The decision taken is stored in the database.

**6.9 Design Class Diagram**
The class diagram for the CRMS is shown in Figure 10. The main building block of a class diagram is the class, which stores and manages information in the system. There are thirteen main classes; user, bank, customer, creditworthiness, credit risk, collateral, loan contract, guarantee, customer verification, RWA computation, capital computation, default risk computation, and report. Each class has properties (attributes) about which information is captured as well as operation that a class can perform. The lines connecting the thirteen classes communicate the relationships that classes have with one another share. By reading the relationship lines the researcher understands that:

   1. A user can do one to many credit risk analysis and can generate one to many reports.
   2. Many users work for one bank.
   3. A customer has account with one or many banks, can provide one or more collaterals and can as well have one or more loan contracts stored in the database.
   4. Each loan contract has one or more guarantee.
   5. Creditworthiness class is required for the computation of credit risk.
   6. Credit risk computation includes customer verification, requires Creditworthiness result, includes default, RWA and capital computation.
7. SYSTEM IMPLEMENTATION

7.1 Choice of Implementation tools/languages and why?

Different web application languages and modeling tool were used to come up with a comprehensive Credit Risk Management system. These include the following: Hypertext Markup Language (HTML), Hypertext Preprocessor (PHP), MYSQL, Cascaded Style Sheet (CSS), JavaScript, Dreamweaver, Fireworks, SWiSHmax and Edraw.

Dreamweaver is an HTML-based application that is used to generate graphical user interfaces. The visual editing feature allows creating a web page without having to type HTML code. Dreamweaver supports graphics created by Fireworks or any other application so that you can easily import those graphics onto the web page. It also provides a coding environment with coding tools for users to edit HTML codes or to include any other scripting language. The scripting language behind the development of the CRMS is PHP. Other Scripting languages used are CSS and JavaScript. JavaScript is used to add functionality beyond standard HTML to a web page. It adds interactivity to web site. Edraw application was used to draw the UML diagrams. The researcher’s choice of PHP and MySQL for this project is because of the following benefits it offers.

MySQL is commonly used together with PHP in website development and is popular open source software. A PHP & MySQL database driven site completely separates content and designing part. This way you only need to update the database and the rest is taken care of by the system.

7.2 Database Management System (DBMS) Implementation

The database server that was adopted for the project is the MYSQL database server. This is mainly because of its easy interaction with PHP-enabled web servers, ability to serve many parallel client requests, its Secured Socket Layer (SSL) and SSH security plug-ins and its cheapness for the project since it is open source when used for academic ends. The web server software chosen for this project was the WAMP (Windows, Apache, Mysql, PHP). This is because of its proven robustness in heavy environments and the fact that they are open source. The DBMS described above entailing the web browsers like Mozilla Firefox, Internet Explorer, Netscape, web server and database server, provides sufficient security functionality, works well in a multi-user environment and it is stable with large volumes of data. The system delivers decision support information to managers using a "thin client" Web browser like Mozilla Firefox , Netscape Navigator or Internet explorer. The server-class computer that is to host the loan decision application is to be linked
to the user’s computer by a network with the TCP/IP protocol. Banks Extrane and Internet is to support a large group of users using web browsers since Nigerian Banks operates in a networked environment. The system employs a web interface (browser based) which is user friendly thereby enabling loan officers to analyze loans within the shortest time possible with no complexities. Below are tables that were implemented.

8. CONCLUSION

Developing a credit risk management system is not simply a question of writing software. It requires a complex interaction of many different people and skill sets within the organization. It also requires a deep understanding of the problem, the ability to determine what needs to be achieved and the ability to develop and execute a plan of action. In this research, critical examination of the possible causes of bad loan in Nigerian banks was done. It was discovered that lack of determining borrower integrity, competence, and risk in a loan transaction are big challenges in the industry. Most of the time, credit booked is bad from the first day as it lacked feasible information on which to drove or manage the facility. The researcher therefore, believed that integrity, competence and determination of credit risk should be the most valuable and important security to granting loan. To offer solution to the problems, this research presented a DNS -based model for CRMS – it is browser - based software that informs lender whether to accept or reject applications for loan, providing output that enables users to understand the reason behind the decision. The DNS approach allows faster flow of information among banks and its business partners, resulting in timely and more intelligent loan decision-making. It also facilitates loan fraud detection. This is achieved by incorporating in the CRMS a Biometrics-based way of tracking fake identity and GPS-based system to uniquely identify collateral in the form of a landed/housing property since the collateral or security remains the lenders recourse. The CRMS also makes use of theoretical and mathematical financial models to estimate credit risk using credit risk scorecard. A complex study is carried to determine a credit score for any business unit or individual involving various factors primarily extracted from the credit report, with payment history providing deep insight into the subject’s financial transactions and lawsuits. It important to note that the CRMS does not decide whether a credit is “adverse.” It is the individual lender or creditor which makes that decision, each lender has its own policy on what scores fall within their guidelines. The specific scores that fall within a lender's guidelines are most often not disclosed to the applicant due to competitive reasons. However, this paper is not saying that CRMS alone will entirely rule out the issue of credit risk but when combined with effective prudential management and supervision of the local banks and enforcement of banking legislation the incidence of NPL should become drastically reduced.

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Professor Inyiama Hyacinth Chibueze is a seasoned computer scientist and engineer, with a wealth of experience in both industry and academics. He obtained his Bachelors Degree in Computer Technology from the University of Wales, University College of Swansea, U.K (1978) before going over to the University of Manchester, Institute of Science and Technology (UMIST U.K.) for his Postgraduate Studies. He obtained his Ph.D (UMISI) in December 1981. Since then he has held several posts nationally and internationally in the field of Computer and Information Technology. He is duly registered professionally as both computer scientist and computer engineer. His writing prowess derives from his wide professional exposure in academics and industry.
APPENDIX A

Input Validation Screen

Credit Risk Input Form
APPENDIX B
SAMPLE OUTPUT

Screen showing Valid Fingerprint

Screen showing Personal History of a Borrower whose Fingerprint is Validated
Loan Officer’s Home Page

Borrower’s Approved Loan Details