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RESEARCH ARTICLE OPEN ACCESS

Design and Implementation of an Online Electricity Payment and Metering System with Payment Integration, Emailing and SMS

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Abstract:

Nigeria's energy sector is plagued by poor, inadequate and disorganized electricity billing and consumer relations management. Despite the introduction of prepaid billing meters, electricity billing and collection remains a major challenge in some communities in Nigeria. Because the electricity consumer must first go to the bank to make the payment and then take the cashier to the electricity company's office to confirm the electricity payment before the electricity is applied to the card. The installment and payment process is tedious and burdensome. The main objective of this research is to design and implement a practical, cashless, automated and transparent electricity metering, billing and payment system.

This study combines the power of the Internet to allow a power meter to communicate with her SMS and email network. Once fully implemented, the proposed system will allow electricity consumers to seamlessly charge and pay their electricity bills remotely via their mobile phones or laptops. The introduction of an online electricity payment and meter reading system will help improve accountability, organize and simplify electricity payments in Nigeria. The proposed system was developed using HTML and CSS, as well as Python and MySQL programming languages.

Keywords **— Billing system, bill payment, Django Framework, e-payment, internet billing, API**

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I. INTRODUCTION

A. Background of Study

Energy is very important in all activities of human daily life. Energy meter is an important part of power supply. An energy meter is a device used to measure the power consumption of electrical appliances in private homes and commercial areas. Energy meters are measured in kilowatt hours (kWh). Kilowatt-hour is the amount of electrical energy that a kilowatt pile uses in his 60 minutes. An energy meter basically consists of a voltage coil and a current loop. The voltage loop measures instantaneous voltage (volts), the current coil measures the instantaneous current (amps). Instantaneous voltage, system result. This electrical system allows both electricity consumers and utilities to remotely monitor electricity usage and consumption. Additionally, customers can pay or "refill" their meters remotely. The system is efficient and anti-corruption, as energy consumption can be estimated remotely by utilities and compared to revenue generated over a period of time. In this study, electronic performance meters with communication networks was combine, in this case SMS and email networks. Remote electricity billing is a unique concept where an online electricity payment and metering system helps increase accountability, organize and simplify electricity bill payments in Nigeria. This helps power management collect data on the units consumed by energy consumers and improve how power is shared. Because each consumer has its own energy meter with a GSM modem, microcontroller unit and display unit. Energy customers can easily pay through an online electricity system without having to queue at a bank,

which allows consumers to pay for what they use or what they can afford. The increase in electricity consumption and its impact on the cost per kWh has necessitated the use and monitoring of efficient energy devices. Measurements therefore monitor energy consumption and usage. Nigeria's energy sector faces inadequate and disorganized billing and consumer relations organizations. Energy billing and collection remains a major problem in Nigeria despite the introduction of prepaid meters. The payment process is cumbersome and stressful as power buyers have to make payment at the bank and then visit the bank counter to the power company's office to confirm the capacity payment before refilling the meter card. The main objective of this work is to integrate SMS and email to notify the user when a payment has been made and the meter card has been used, without having to go to the bank, in a convenient, cashless and computerized way with SMS and email integration to notify users when payments are made and their meter card energized.

A unique feature of this system is that once a consumer is disconnected or has used up their allocated energy, they can make a payment from anywhere in the world via their mobile phone or laptop. After payment confirmation, the connection will be automatically restored. The project runs on an Internet network, so the system can be accessed from anywhere in the country.

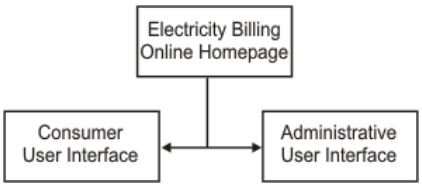

Fig. 1: Block diagram showing the Proposed Online Electricity Billing System.

B. *Statement of the Study*

In Nigeria, electricity consumers often face the problem of queuing up at banks and struggling to pay their prepaid electricity bills. Even after payment is completed, you must bring your payment receipt to the electricity management office to recharge your prepaid meter. This causes delays and is a detriment to our community. Businesses that use electricity for production purposes also suffer significant losses when electricity is cut off and the allocated energy is used up. Therefore, it is important to create an effective and efficient online system through Internet platforms that ensures smooth payment of prepaid electricity bills. This study demonstrates the importance of the design and functionality of a web-based application with online functionality called Online Electricity Payment and Metering System.

C. *Aims and Objectives of the study*

The main objectives of this study are to design and implement an online electricity payment and metering system that will enable electricity users across Nigeria to seamlessly charge electricity meters across Nigeria with the following objectives:

1. Prepaid energy credit payments over the internet with SMS and email notifications.
2. Automatic credit and electricity consumption allocation for consumers immediately after payment.
3. Send SMS and email alerts after payment or when balance is low.
4. Submit energy consumption information to the energy supply office.
5. Securing Payment and Billing Transactions.
6. Enhancing accountability in Nigeria's energy sector.

II. THE PROPOSED SYSTEM

Considering the anomalies into the existing system, a computerized system is built using Python as a base language. The system enhances and upgrades the old existing system by increasing its efficiency and effectiveness. The software improves the working methods by replacing the existing manual system with the computer-based system. The proposed system automates each and every activity of the manual system and increases its throughput. Thus the response time of the system is less and works very fast. The system uses a quick response with very accurate information regarding the user's electricity bill information. The proposed system has a very user friendly interface, thus the user will feel very easy to work on it. The software

provides accuracy along with a pleasant interface. The transactions reports of the system can be retried as and when required. Thus there is no delay in the availability of any information, as whatever will be needed, can be captured quickly and easily. HTML and CSS will be used as a front end and The Microsoft Structured Query Language (SQL) as back end for developing the project. Visual studio code (VS Code) is primarily a visual design environment. This design environment will be used to create text boxes, buttons and adding support codes in the respective modules (the administrator and user modules). The Microsoft SQL server is a powerful database application with which the user can efficiently create and manipulate database systems.

A. System Modules and their Description

The system comprises of two major units, which are further divided into sub-units. They are as follows:

1. Administrative Login: In the administrative login, the administrator has the authority of the system. The administrator can add, delete notifications and update the system. The administrator performs the following functions on the system:

- Consumers Registration: The Admin will register the consumer by entering the consumer's basic registration details such as: Name, Contact Address, Residential Address, Consumer type, Password and Email Address.
- View Registered Users: The Administrator can also view all the registered users in the system, make necessary updates and update the bill status of the consumers.

2. Consumer Login: Consumers can login into the system and perform the following tasks:

- View Bill: Consumers can view their balance electricity bill amount of each month.
- Consumption Calculation: Consumers can calculate the total amount of units they consume in a month using a consumption calculator.
- Bill Calculation: Consumers can calculate the total number total amount that he/she will pay based on the units consumed, using a bill calculator.

B. System Flow Chart

The model of the proposed system is shown in a flowchart. All of these models provide a conceptual view of user requirements and provide graphical analysis. As an important modeling tool, entity-relationship diagrams help organize the functional elements of a system into entries and define relationships between entities. This process allows analysts to understand the structure of the database and to store and retrieve data in the most efficient manner. This flowchart shows the flow of data from external entities to the system. It also shows how data is transferred from one process to another and how data is logically stored. Figures 2 and 3 show flowchart activities for administrators and consumers, respectively.

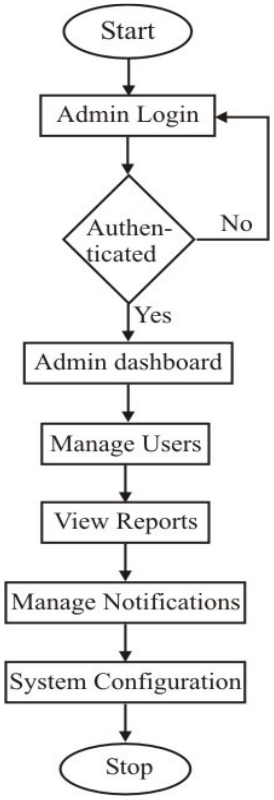

Fig.2: Flowchart for Admin User

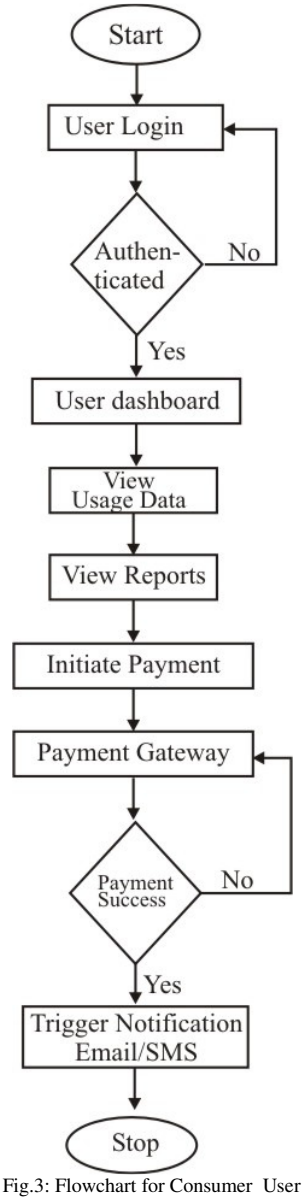

Fig.3: Flowchart for Consumer User

These flowcharts provide a visual representation of the processes involved for both admin and consumer users in the online electricity payment and metering system.

III. SYSTEM IMPLEMENTATION AND OPERATION

A. System Implementation:

Used Visual Studio Code development environment for front-end and Django framework for back-end development. Smart meters have been integrated with established communication protocols between the system and smart meters. APIs are intended to enable data exchange in real time. A thorough audit was then conducted to ensure accurate and secure capture of meter data. Paystack Gateway is integrated for seamless and secure online transactions. Implemented payment processing logic to ensure compliance with financial security standards. Extensive testing of payment flows in various scenarios.

Email and SMS Integration: Various templates was configured for notifications (billing statements, payment confirmations).

Security Measures implemented are:

- Implemented SSL/TLS encryption for secure data transmission.
- Employed secure coding practices to mitigate potential vulnerabilities.
- Regularly updated security protocols based on industry standards.

B. System Operation

- User Authentication:

- Implemented robust authentication mechanisms.
- Enforced secure password policies and, where applicable, multi-factor authentication.

- Dashboard Functionality:

- Provided an intuitive dashboard for both admin and consumer users.
- Enabled easy navigation and access to relevant functionalities.

- Meter Data Display:

- Enabled consumers to view real-time electricity consumption data.
- Ensured accurate and timely updates from smart meters.

- Payment Process:

- Facilitated a seamless payment process through the integration of a secure payment gateway.
- Updated user accounts promptly upon successful transactions.

- Notification System:

- Automated the sending of email and SMS notifications based on user actions and system events.

- Configured notification preferences for users.

- Admin Operations:

- Provided admin users with tools to manage consumer accounts, access reports, and configure system settings.
- Implemented role-based access controls for heightened security.

- Monitoring and Maintenance:

- Implemented monitoring tools to track system performance.
- Established routine maintenance protocols for updates and improvements.

- User Support and Training:

- Developed user training materials.
- Offered ongoing user support for any system-related queries or issues.

C. Load Consumption Calculation

Load consumption refers to the total amount of electrical energy consumed by a system or device over a specific period. It is typically measured in kilowatt-hours (kWh). The load consumption can be calculated using the following formula:

$$\text{Load Consumption (kWh)} = \frac{Power(kW)\ X\ Time\ (hour)}{1000}$$

Where:
- Power (kW)} is the power of the electrical device or system in kilowatts.
- Time (hours) is the duration for which the device or system is in operation in hours.

This formula essentially multiplies the power (in kilowatts) by the time (in hours) to obtain the total energy consumption in kilowatt-hours.

Load Consumption Calculation during test:

There was scenario where a household appliance has a power rating of 1.5 kW and operated for 3 hours.

$$\text{Load Consumption (kWh)} = \frac{1.5(kW)\ X\ 3hour}{1000}$$

$$= \frac{4.5kWh}{1000}$$

Load Consumption (kWh) = 0.0045kWh

So, the load consumption for the household appliance operating for 3 hours is 0.0045 kWh. This value represents the total energy consumed during the specified time period and is essential for understanding and managing electricity usage efficiently.

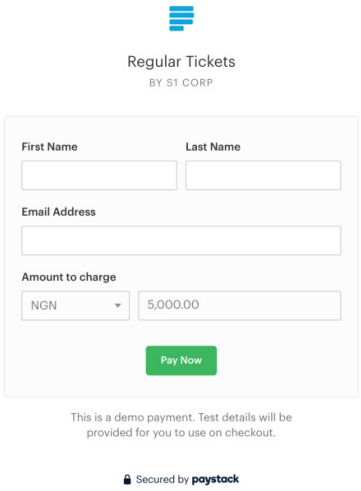

Fig. 4: Paystack Payment Gateway Page

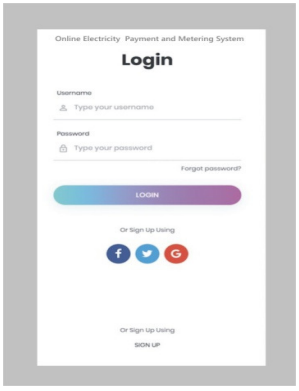

Fig. 4: Admin/Consumer Login Page

V. CONCLUSIONS

In conclusion, the design and implementation of the integrated online electricity payment and metering system with payment integration, emailing, and SMS functionality represent a significant leap forward in modernizing and optimizing the electricity billing process. The seamless integration

with smart meters provides users with real-time insights into their electricity consumption, fostering a culture of awareness and efficiency.

The secure payment gateways ensures a convenient and secure transaction experience for users, reinforcing trust in online payment processes. The automated notification system through email and SMS not only enhances user communication but also serves as a proactive means to keep users informed about billing cycles and important updates, contributing to an improved overall user experience.

The robust architecture, featuring a user-friendly web portal, strong authentication mechanisms, and a secure database, underscores the commitment to data integrity, privacy, and security. By adhering to industry best practices, including SSL/TLS encryption, the system safeguards sensitive information, instilling confidence in users regarding the protection of their personal and financial data.

This implementation serves as a noteworthy model for utilities sectors aiming to modernize their billing systems, emphasizing efficiency, user-centric design, and enhanced communication channels. As technology continues to evolve, this integrated system stands at the forefront, showcasing the potential for digital solutions to positively impact and transform traditional processes in the utilities domain.

In the ever-changing landscape of technological advancements, the success of this integrated system sets the stage for future innovations in utility services, inspiring further exploration and development in creating intelligent, secure, and user-friendly solutions that meet the evolving needs of consumers in the digital age.

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This journal is a testament to the collective effort, dedication, and collaboration of all those involved, and I'm truly grateful for the opportunity to contribute to the discourse on advancing utility services through technology.

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