Development of Prepaid Electricity Payment System for a University Community Using the LUHN Algorithm

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Abstract. This work presents a University Community based electricity prepaid billing system. Generally in Nigeria, electricity customers face a lot of problems with respect to their electricity bills from the distribution companies. The challenges they face include wrongly calculated bills as a result inaccurate reading of meters, general human errors in bill preparation among others. In some other semi-automated systems in which prepaid meters are used, consumers waste much time in purchasing utility units for electricity. This is the case presently at the university community we are considered in this work. This paper presents the design and implementation of a combination of a web-based and SMS alert prepaid electricity system called for the community. The implementation of the system was done using C# programming language and Microsoft SQL Server as the database platform. The system incorporates the Luhn algorithm for generating pins for use on the simulated prepaid meters. The system is able to run on the university intranet and can also serve as internet based application.

Keywords: Prepaid electricity · Luhn algorithm · Payment system · Pin

1 Introduction

Prepayment utility meters systems medium through which customers purchase utility units that enable them use services like electricity, water, waste, cable among others, in advance [1]. The introduction of prepaid meters in the early part of last decade was received with great expectation that billing issues would be over. It was a feeling of freedom at last from the erstwhile electromechanical meters used for billing at that time. The use of prepaid meters for billing electricity consumption was to eliminate most of the challenges hitherto faced with use of the old meters. Such challenges include wrongly calculated bills as a result inaccurate reading of meters; general human errors in bill preparation; payment of bills through wrong agents among several others. The prepaid meters on the other hand brought about a number of benefits to both users and system that include [1–3] elimination of monthly bills or collection hassles; reduced operational costs; elimination of disconnects and reconnects; immediate collection of revenue; among others. The prepaid meters work by measuring actual electrical use and removing units in real-time [2].

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Although these benefits exist, there is the need to take advantage of the advances in technology to further improve on the benefits. For instance in the Covenant University community which we considered for this work, the processes leading to the final purchase of electricity units appear to be long and inconvenient to most consumers. Consumers in need of electricity units usually have to first pay the amount required at the bank, convert the duplicate teller to a receipt before going to the point of purchase. The question to ask is whether it is possible to evolve a system that eliminates all these unnecessary procedures that waste time. It is in response to this, that a simple prepaid system was proposed as a solution to the issue.

There have been several efforts in Nigeria and other parts of the world to build similar systems for various reasons and needs of people. In 2006, [4] designed and implemented a SMS-based control for monitoring systems. The SMS component was used for status reporting such as power failure. However, the work did not consider issues that concern billing for electricity usage.

The work of [5] proposed a method for using telecommunication systems to automate transmission of data to facilitate bill generation at the server end and also to the customer via SMS, Email. [6] also developed a card reader-based prepaid electricity metering system but for a multiphase system. The work of [7] focused on the controlling of home appliances remotely and providing security when the user is away from the place using an SMS- based wireless Home Appliance Control.

[8] developed an energy efficient and low cost solution for street lighting system using Global System for Mobile communication [GSM] and General Packet Radio Service [GPRS]. The whole set-up provides the remote operator to turn off the lights when not required, regulate the voltage supplied to the streetlights and prepare daily reports on glowing hours.

[9] proposed in their paper, a prepaid energy meter behaving like a prepaid mobile phone. The meter contains a prepaid card analogous to mobile SIM card. The prepaid card communicates with the power utility using mobile communication infrastructure. Once the prepaid card is out of balance, the consumer load is disconnected from the utility supply by the contactor. The power utility can recharge the prepaid card remotely through mobile communication based on customer requests. The work of [12] focused on the design and implementation of an intelligent sms-based remote metering system. [10, 11] are both online and web-based platforms respectively for bill payments but not for prepaid purposes.

In this paper therefore, we present the design and implementation of a web-based electricity prepaid system for a university community. The remaining sections of this paper are divided into review of related work, system requirements, system design and modeling, system implementation and conclusion.

1.1 Luhn Algorithm

The LUHN formula was created by IBM scientist Hans Peter Luhn and described in U.S. Patent No. 2,950,048, filed on January 6, 1954, and granted on August 23, 1960 [10]. Because the algorithm is in the public domain, it can be used by anyone. We used an algorithm based on the luhn algorithm for the generation and verification of the pin

created by the system. The LUHN formula is widely used to generate the check digits of many different primary account numbers. Almost all institutions that create and require unique account or identification numbers use the Mod 10 algorithm. The algorithm is in the public domain and is in wide use today. It is specified in ISO/IEC 7812-1. It is not intended to be a cryptographically secure hash function; it was designed to protect against accidental errors, not malicious attacks. Most credit cards and many government identification numbers use the algorithm as a simple method of distinguishing valid numbers from mistyped or otherwise incorrect numbers.

Based on ANSI X4.13, the LUHN formula (also known as the modulus 10 – or mod 10 – algorithm) is used to generate and/or validate and verify the accuracy of credit card numbers.

Most credit cards contain a check digit, which is the digit at the end of the credit card number. The first part of the credit-card number identifies the type of credit card (Visa, MasterCard, American Express, etc.), and the middle digits identify the bank and customer.

To generate the check digit, the LUHN formula is applied to the number. To validate the credit-card number, the check digit is figured into the formula.

Here's how the algorithm works for verifying credit cards; the math is quite simple:

i. Starting with the second to last digit and moving left, double the value of all the alternating digits.
ii. Starting from the left, take all the unaffected digits and add them to the results of all the individual digits from step 1. If the results from any of the numbers from step 1 are double digits, make sure to add the two numbers first (i.e. 18 would yield 1 + 8). Basically, your equation will look like a regular addition problem that adds every single digit.
iii. The total from step 2 must end in zero for the credit-card number to be valid.

2 System Requirements

A requirement states what a product or service is intended to perform. It takes into consideration the attributes and characteristics that a system is expected to possess so as to meet the need of a user.

i. Users and Administrators must login to access the services.
ii. Users must be able to provide required information when required to.
iii. The system should provide a notification to customers showing success or failure of their transaction which could serve as a receipt.
iv. The system should be able send an email containing the pin to a user's email address.
v. The system should be able to display available amount of electricity energy credit units for purchase and the price.
vi. The system should be able to provide a payment method.
vii. The system should keep transaction history.
viii. The system should be able to generate electricity energy credit units pins for STS Meters.

ix. The system should be able to verify legit pin and give notification of wrong or already used pin.

3 System Design and Modeling

System design is the process of defining the components, interfaces, modules, data and architecture for a system to satisfy the specified requirements. This could also be seen as the applications of systems theory to product development. Modeling helps the system analyst understand the functionalities of the system. It is also used to validate the software requirement by examining from a different point of view. Modeling is used to design a software application before coding begins. The Unified Modeling Language (UML) is used in this paper to describe the system from various perspectives.

3.1 Activity Diagram

The activity diagram depicts the workflow of activities within the system. It graphically represents the flow of performance of various actions by the system entities. The flow of the system activities for the administrator is as shown in Fig. 1 below.

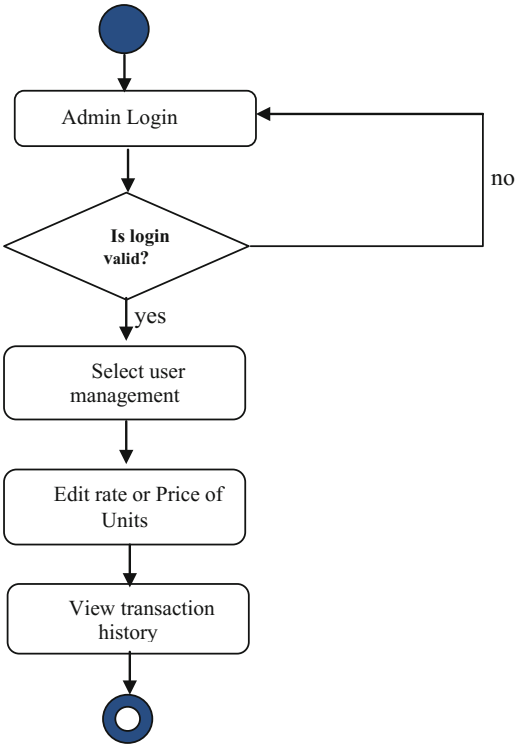

Fig. 1. Activity diagram for administrator

3.2 Sequence Diagram

This is an interaction diagram that shows how processes operate with one another and what is their order. It shows object interactions arranged in time sequence and depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. In Fig. 2 below, the login details of administrator are validated before access is granted to the application.

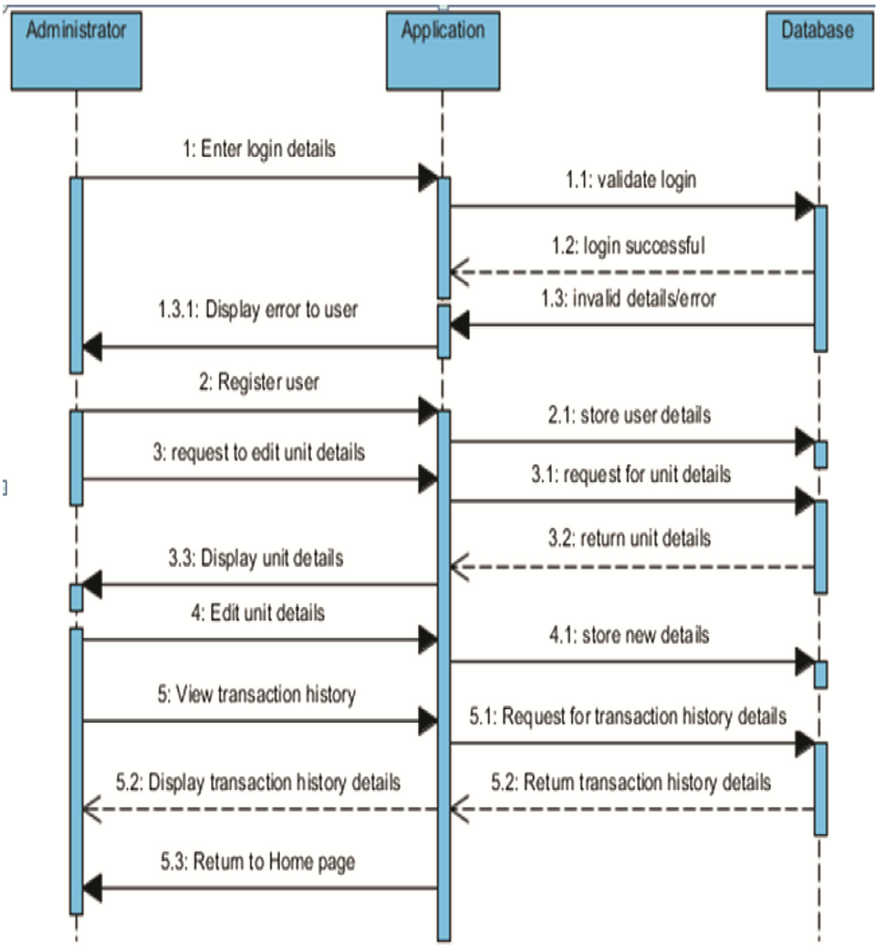

Fig. 2. Sequence diagram for administrator's activities

4 System Implementation and Comparison

SQL Server Management Studio (SSMS) was used as the relational database due to its flexibility easy to use GUI and the easy integration it allows for with Visual Studio as

they are both products of Microsoft. Bootstrap was used to style the web interface of the system to ensure easy and user friendly GUI. Visual studio 2012 was used as the Integrated Development Environment (IDE) and ASP.Net and C# as backend for design of this project. Visual studio was used because of its adaptability. The implementation consists of three major modules which are user interface, energy meter interface and administrator interface. Figures 3 and 4 below are sample snapshots of the system implementation.

Figure 3 below represents the user-friendly login screen. To gain access into the system, a user is required to supply a valid email and password for authentication. The use of email for login purpose was adopted because it easy for users to remember emails. Emails are also unique worldwide and this eliminates issues of collisions in usernames. The use of email also makes it easy to contact a user in case of emergency. Figure 4 shows a pin (4012331580375712) that was generated using the Luhn algorithm and loaded on the application. The new balance (00781.11) also shows on the virtual meter.

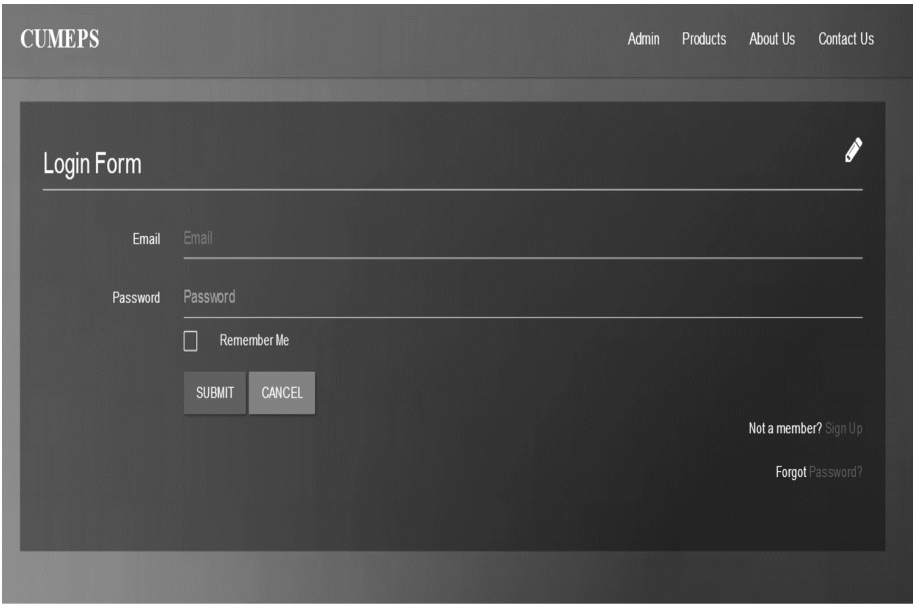

Fig. 3. General login screen

The system developed has improved features when compared with other existing systems that perform similar functions. Some of the features include ease of use, better performance, and friendly user interface, among others. The testing methods applied to the application included unit and integration testing in line with software development standards. Unit testing was used to test individual modules in order to locate local errors. With unit testing, a system developer is able to detect errors in coding and logic in each module. Integration testing on the other hand was carried out to discover errors associated within the interface.

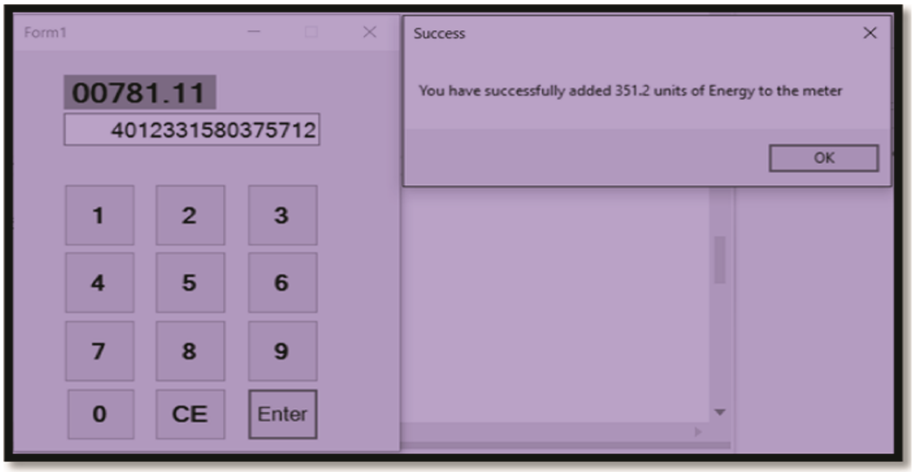

Fig. 4. Adding of units purchased after successful validation of the pin

5 Conclusion

The covenant university community electricity prepayment system was conceptualized following the consideration of the procedures involved in the former system. With this new platform, members of the community can from anywhere initiate and purchase electricity utility units. The developed system followed a simple software development approach of system analysis, design and implementation. The application is web-based and runs both on the intranet and internet. The system was properly tested for accuracy and performance-related functionalities. To further improved on the system, in the future we intend to extend the application to a mobile app in order to cater for convenience and usability attributes of the present one.

References

1. Bruce, W.: Prepayment utility meter systems: a case study from Aleut region (2006). https://www1.eere.energy.gov/tribalenergy/guide/pdfs/cs_aleutian_pribilof.pdf
2. Omijeh, B.O., Ighalo, G.I.: Design of a robust prepaid energy metering and billing system. J. Res. Natl. Dev. **10**(3), 146–153 (2012)
3. Directinsite: Advantages of electronic payment system. www.directinsite.com (2016). http://www.directinsite.com/The-Advantages-of-an-Electronic-Payment-System#sthash.3cNiWrYP.dpuf
4. Stanescu, D., Ciubotaru-Petrescu, B., Chiciudean, D., Cioarga, R.: Wireless solutions for telemetry in civil equipment and infrastructure monitoring. In: 3rd Romanian-Hungarian Joint Symposium on Applied Computational Intelligence (SACI) (2006). http://www.bmf.hu/conferences/saci2006/Ciubotaru.pdf
5. Sharma, S., Shoeb, S.: Design and implementation of wireless automatic meter reading system. Int. J. Eng. Sci. Technol. (IJEST) **3**(3), 2329–2334 (2011)

6. Ling, Z., Sihong, C., Biao, G.: The design of prepaid polypase electricity meter system. In: IEEE Conference on Intelligent Computing and Integrated Systems (ICISS) (2010)
7. Malik, S.H., Aihab, K., Erum, S.: SMS-based wireless home appliance control system (HACS) for automating appliances and security. Issue Informing Sci. IT **6**, 887–894 (2009)
8. Maheswari, C., Jejanthi, R.: Implementation of energy management structure for street lighting system. J. Mod. Appl. Sci. **5**, 6–10 (2009)
9. Amit, J., Mohnish, B.: A prepaid meter using mobile communication. Int. J. Eng. Sci. Technol. **3**(3), 160–166 (2011)
10. Luhn, H.P.: US Patent 2,950,048 - computer for verifying numbers, 23 August 1960. Luhn algorithm. http://www.google.com/patents/US2950048. Accessed 1 May 2016
11. 1000 Projects: Web based bill payment utility CSE project. 1000projects.org (2016). http://1000projects.org/web-based-bill-payment-utility-cse-project.html
12. Wasi-ur-Rahman, M., Tanvir, A., Lutful K.: Design-of-an-intelligent-SMS-based-remote-metering-system. In: International Conference on Information and Automation, ICIA 2009, pp. 1040–1043 (2009)