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Integration of Unstructured Supplementary Service Data (USSD) Into A University's Portal

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Abstract

Though universities have web portals that students can visit to get information about their course of study, the web portal contains too many features (personal data, course of study data, payments, hostel allocation, etc.) which become overwhelming for students. In addition, poor internet services and high cost of data subscription has always been responsible for the frustration of students to access information in university portals. This study presents a system that uses Unstructured Supplementary Service Data (USSD) and internet technology to help students find specific information in the university portal, seamlessly.

1. Introduction

Mobile communications technology has rapidly become the top priority means of relaying voice, data, and other services around the world. Due to their wide availability and inexpensive services, they have the potential of being the best means of disseminating information**.** [1] supported that mobile technologies (i.e. SMS, USSD, geo-location e.t.c) are nowadays used in the domains of citizens' participation [2], public awareness [3], management of emergencies and crisis [4], provision of public services [5], information, etc. to reach wider population segments (as compared to those currently accessing the internet.) The USSD, which means Unstructured Supplementary Service Data, also sometimes called "quick codes" is a communication protocol technology used by the Global System for Mobile Communication (GSM) cellular phones to relay information. Tertiary institution applications are needed to be built around the USSD services to take advantage of USSD technology which is internet independent.

Most tertiary institutions have developed a window on the web technology to convey information to students, staff, and management concerning the business of the institutions through the popular channel called the internet. Portals or websites have been developed by institutions to provide easy access to information without visiting the physical locations of the institutions. Although the introduction of these internet services has proven to be very effective, it still has several limitations such as service disruptions, relatively high cost of data subscription and bandwidth, and poor service penetration, amongst others. This study proposed the use of the USSD technology as a solution to some of these challenges.

The advantages of using USSD include the following: it does not require an internet or data network subscription to function, it works on every mobile phone, it works globally, the two-way communication is faster than SMS, it is intuitive with real-time interactivity, amongst others.

The USSD technology has proven to be very efficient in relaying messages to the public in terms of reaching where the internet has failed due to limitations. It allows a two-way exchange of a sequence of data in real-time which make it a responsive tool for relaying information. Integration of this USSD service in a tertiary institution portal or website would create a reliable means of unlimited access to information where users can communicate with an application that works through mobile channels, seamlessly and at lower costs. These features of USSD motivated this study.
Poor internet services and costly data have always been responsible for the frustration of students to access information on most university portals in developing countries. The applications of the USSD technology will enable students in the University of Benin with any phone (internet or non-internet enabled) access the University portal seamlessly. Thus, students may not need internet services nor buy data to access the information on the portals

This study developed a USSD menu-based application where students can get access to unrestricted information with any phone (internet and non-internet enabled), from any part of Nigeria without the use of the internet. The system is expected to achieve the following: (i) provide access to the University of Benin portal with any type of mobile device. (ii) provide offline services for students who do not have data to go online. (iii) easy navigation for students to get access to academic updates and information. (iv) ensure easy checking of student results and payment status. The study is restricted to a selected USSD technology service, specifically USSD gateway and is limited to Computer Science Department, University of Benin, Benin-City.

1.1. Related Work

[1] demonstrated how USSD platform could be in cooperated in online student registration system. The system enabled staff of each academic department to examine the modules offered by their departments, add, remove modules and change the information about them. The aim was to enhance the reach of facilities to the target users using the most popular and commonly available technology with student populations. [6] presented MIRCS, a low-end USSD-SMS based system designed for checking Higher Education semester results in resource limited settings like Africa. Students were able to access MIRCS without internet using any type of phone, including basic phone. The system was designed by working with users from a Higher Education Institution in a developing country. Based on trials with 784 students, the system recorded up to 89% successful access rate from recorded 3136 USSD sessions over four telecommunication networks. [7] used the concept of USSD technology to propose a proof-of-concept solution for bank cash deposits which could save time and resources for customers and the bank. To achieve this, an information system was developed which operated a voucher card technology and assisted in reducing waiting and service times. The USSD communication was simulated using wireless connection between two computers acting as user's mobile phone and the banks deposit voucher system respectively.

2. Methodology

The study used a selected USSD technology service, specifically USSD gateway. The skeleton of the USSD gateway application was designed using the UML diagrams, like use cases, class diagrams, etc. The integration of the USSD gateway application was developed by using the designed diagram and programming was done using PHP. The database management was done with PostgreSQL from a clue of the University of Benin online portal.

2.1. Systems Analysis and Design

2.1.1. The Present System

The University of Benin Kofa Portal provides basic information related to students' academic records, registration, and assessments, in addition to allowing students submit their requests and transactions through the internet (https://waeup.uniben.edu/). Bonafide students are given accounts with username, and passwords, to access and login to the University of Benin Kofa Portal. This enables them to access this portal via internet and to conveniently get information about their studies, amongst others (https://waeup.uniben.edu/).

In gaining access to the academic information and services, the University of Benin Portal has a series of activities lined up for students as follows:

i. Each student must have a record with the University of Benin with a unique login detail.
ii. Students must login with their unique login details on the University of Benin Kofa Portal
iii. Click on Academic tab on the navigation tab.
iv. Student will find the faculty they are in and click the link
v. Student will click on the preferred department they are in
vi. Student will find the courses they offer and check for the details.

One of the major issues that discourage students from utilizing a university portal is the long process of navigation, and the non-provision for off line accessibility. It is hoped that the proposed system will reduce some of these challenges.

2.1.2. The Proposed System

We highlight the different components of the proposed system as follows:

SIGN UP: This component will enable unregistered students to create a profile for the USSD service.

SIGN IN: For students already registered for this service, this component will enable automatic login for existing users.

SESSIONS: This component enables students to request academic information from the USSD application.

DATABASE: This database will contain records of students.

Our proposed system will adopt the USSD architecture given by [8] and depicted in Figure1

Figure 1 shows the USSD architecture as given by [8]

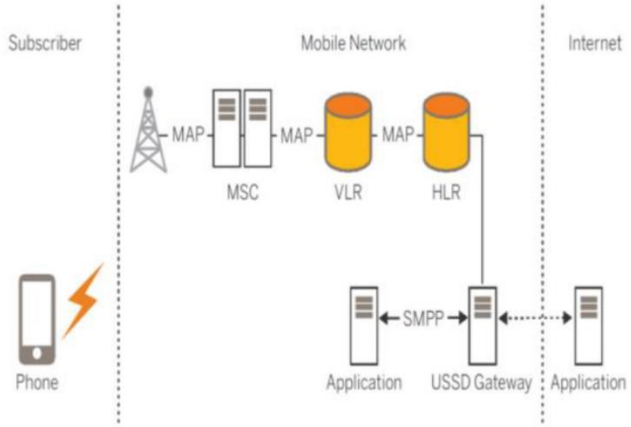

Figure 1: Architecture of USSD (Elements of the USSD Mobile Network: [8]).

According to [8] and cited by [9], the USSD architecture basically comprises the following: (i) The network part that includes the Home Location Register (HLR), Visitor Location Register (VLR), and MSC (ii) Simple Messaging Peer-Peer (SMPP) interface for applications to enable services (iii) USSD Gateway and all specific USSD application servers.

As submitted by [9], the USSD seems to be a complex architecture, thus, this study did not focus in analyzing USSD architecture but utilized it as a hologram. The same approach was used by [9]. Thus, this study is concerned with the mobile (phone) and USSD Gateway aspects of the architecture. A USSD gateway (also called a USSD center) service transmits USSD messages from the signaling network to a service application and vice versa [10]. The gateway is based on the ability of the delivery agent or the source to send and receive USSD messages [10]. These messages travel over GSM signaling channels and are used to query information and generate services [10].

2.2. Design Models

The models provide a visual representation of the system, providing behavioural or structural specification of the system being designed. It provides a way for mapping out the blueprint of the system and explains the core functionality and flow of data in the system. The following diagrams were used to model the system:

2.2.1. Activity Diagram

This is an important diagram in UML for modeling the dynamic aspects of a system [11]. It models the flow from one activity to another and describes how activities are coordinated to provide a service which can be at different levels of abstraction (https://www.visual paradigm.com/guide/uml-unified-modeling-language)). The activity diagram for this system is a behavioral specification of the system and highlights the flow of activity from signing up to concluding a session. The activity diagram of the proposed system is depicted in Figure 2.

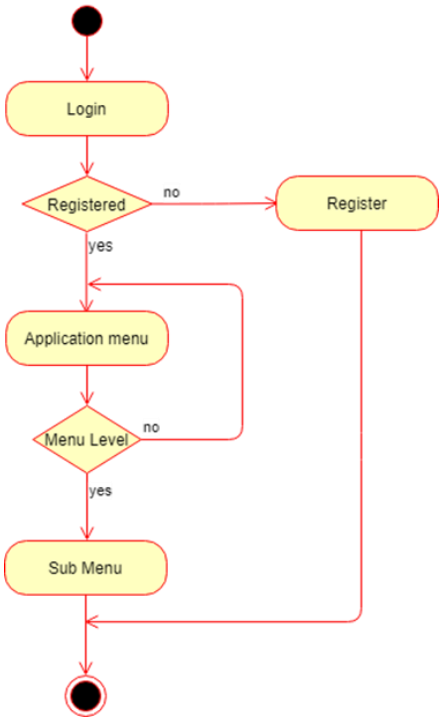

Figure 2: Activity diagram of the proposed system

2.2.2. Use Case Diagram

This is a behavioural diagram in UML that shows the relationships among actors and use cases within a system. It shows the interactions between a system and its users, or actors and is used to represent and model the functionality of a system (https://study.com/learn/lesson/use-case-diagram-template.html).

. "Actors" in this context are people or entities that operate on defined roles in the system. In this model there is only one actor identified as follows:

Students: The student's main role is to get academic information about his/her course of study and the condition that must be met before accessing the information would be having a valid account. The model depicts the actions to be taken to achieve this. The model in Figure 3 is a use case diagram that shows the actor and the different actions that can be carried out on the platform.

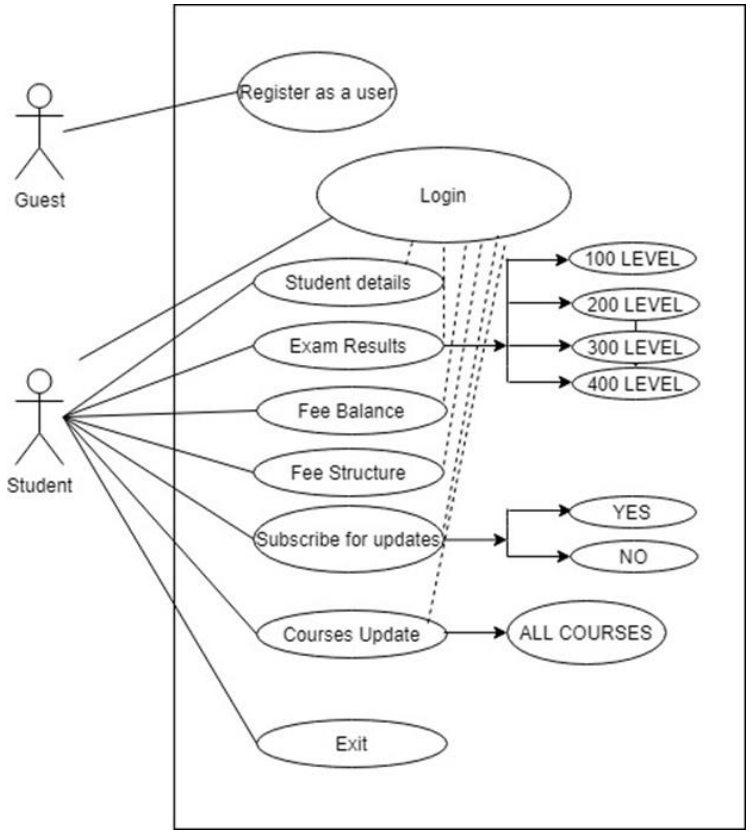

Fig3: Use Case diagram of the proposed system

2.2.3. Class Diagram

The UML class diagram is a graphical notation used to construct and visualize object oriented systems (https://www.visual-paradigm.com/guide/uml-unified-modeling-language/uml-class-diagram-tutorial/). It depicts a static view of an application and shows the attributes, classes, functions, and relationships to give an overview of the software system. (https://www.javatpoint.com/uml-class-diagram). Figure 4 depicts the class diagram for student module which describes their major functionalities.

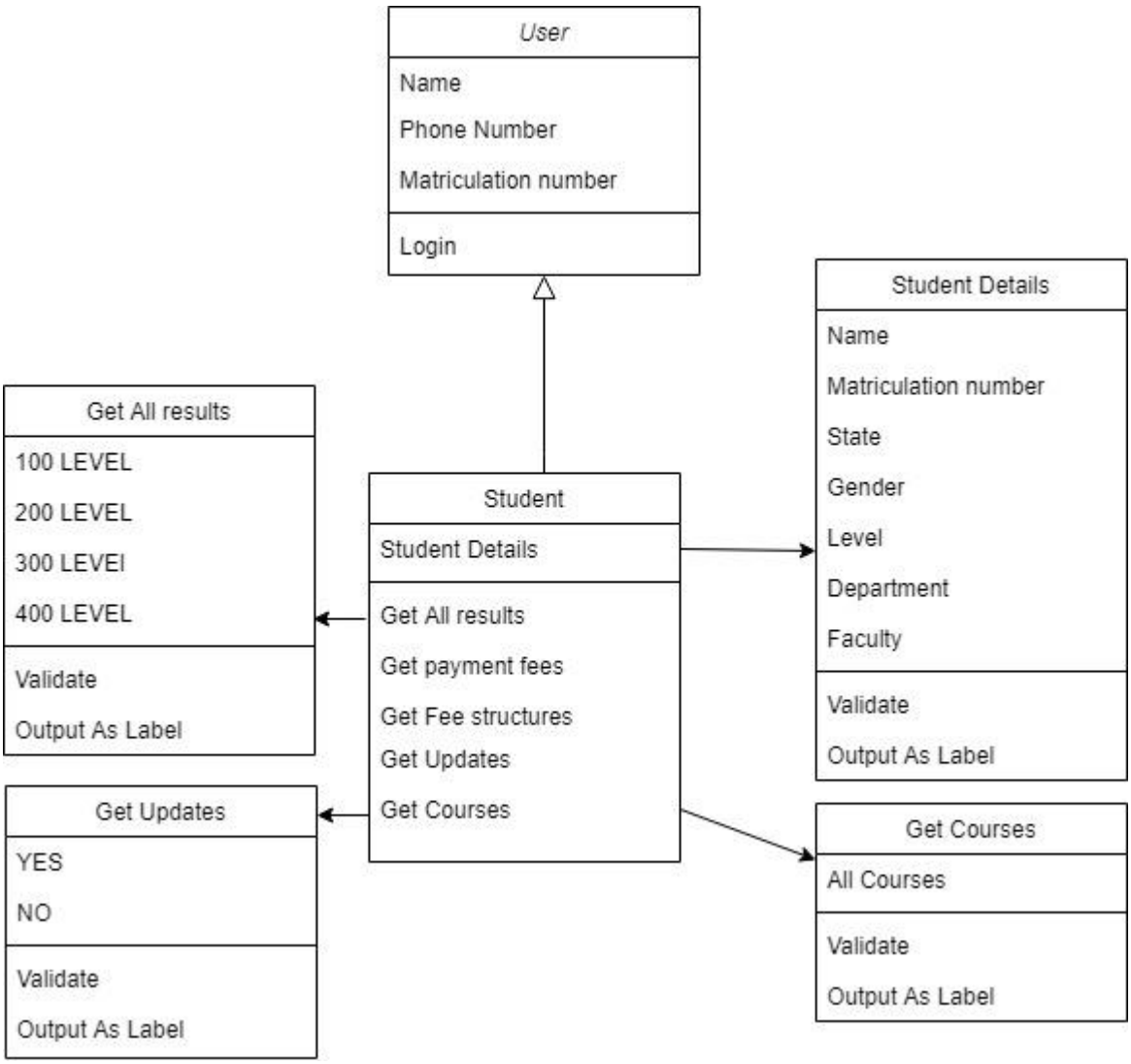

Figure 4: Class diagram of the proposed system

3. Implementation and Testing

Here, we discussed the implementation of the software and other requirements to develop the system; such as the system requirements, justification of programming languages and frameworks, Database Management Systems (DBMS) and tool kits.

3.1 System Requirements

3.1.1. Hardware Requirements

This requirement specifies the hardware tools needed for the development and deployment of the USSD application. Since this system is built for a mobile phone, the devices used in running and testing the USSD application would include a computer system and a mobile phone. The USSD application would require the following hardware:

A mobile phone with the following minimum requirements:

i. Processor speed: 1.3Ghz and above

ii. Android: version 4.2 and above
iii. RAM: minimum 512Mb
iv. Internal storage: minimum 2GB

A computer system with the following minimum requirements:

i. Processor: Core i3 and above with a speed of 1.8GHz and above
ii. System memory: 128Mb minimum 1GB recommended
iii. RAM: At least 2GB
iv. Network card: Any card that can provide a 100mpbs speed
v. Hard disk: 80GB and above

3.1.2. Software Requirements

The minimum software requirements for the USSD based academic portal system are:

i. Windows XP Operating system or higher
ii. Visual Studio Code
iii. SVGA Display drives
iv. PostgreSQL Application server

The tools used for developing the system are described as follows:

PHP: PHP, a recursive acronym for Hypertext Preprocessor, is an open-source server-side scripting and general- purpose language that is used for web development and can be used to make lots of projects, including Graphical User Interfaces (GUIs**)** ((https://www.freecodecamp.org).

Africa's Talking: This is a mobile technology company that offers developers integrated mobile APIS to simplify the processes involved in interacting with SMS/ USSD / Voice and Airtime (https://africastalking.com/**).**

PostgreSQL: This is object-relational open source database system with distinct attributes of, performance, feature robustness and reliability (https://www.postgresql.org/) and designed to handle a range of workloads, from single machines to data warehouses or web services with many concurrent users (https://www.postgresql.org/).

3.2 Implementation

3.2.1. Simulation Application

This API channel routes the dialed code to request the application which is displayed for accessing. Figure 5 shows the API channel for running the USSD code.

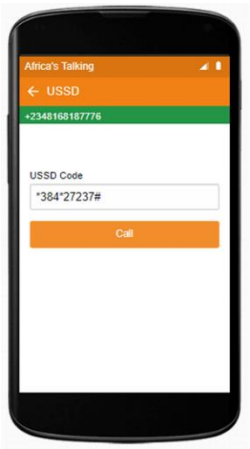

Figure 5. Africa's Talking API USSD Channel

3.2.2. Registration Screen

This USSD page gives the students the opportunity to register with the provided details on the screen. The students must provide valid details. Once the student finishes the registration and is validated, a user record is created and stored on the database for authentication. This is depicted in Figure 6.

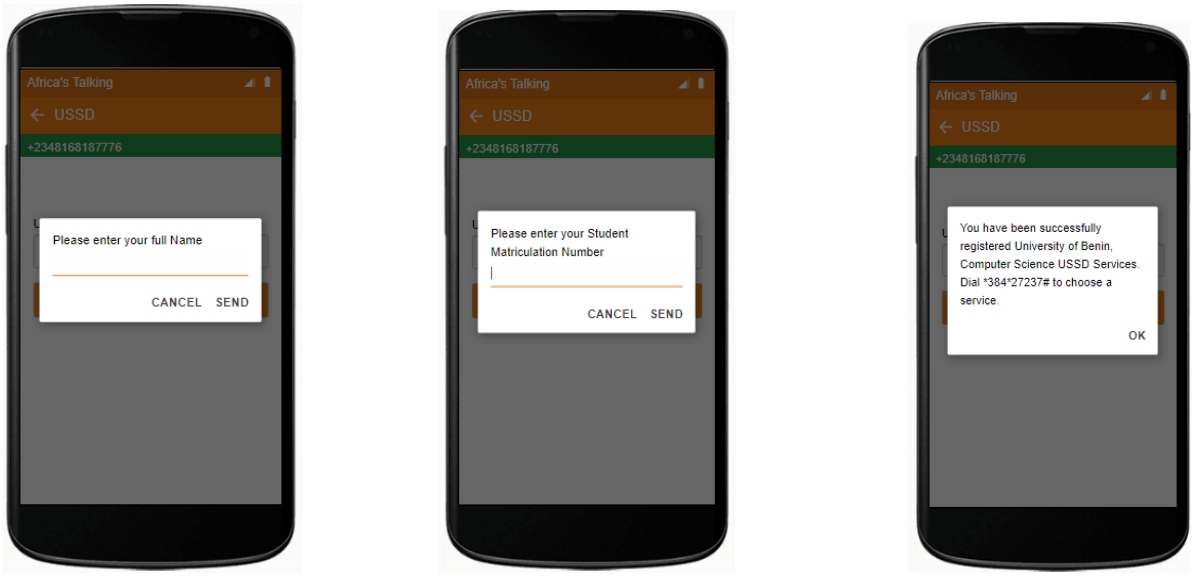

Figure 6: Registration screens for new users of the USSD application

3.2.3. Main Menu

The USSD application contains a main menu which enables students navigate through different academic services. Figure 7 shows the main menu of the USSD application

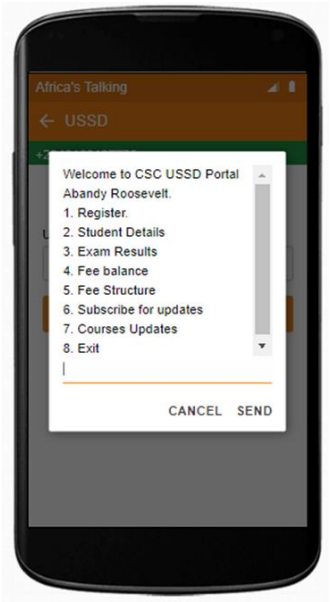

Figure 7: Main Menu of the USSD application

3.2.4. Sub Menu

The Menu contains some subcomponents of the main menu for easier navigation through different levels of academic services. Figure 8 shows the sub menus of the USSD application.

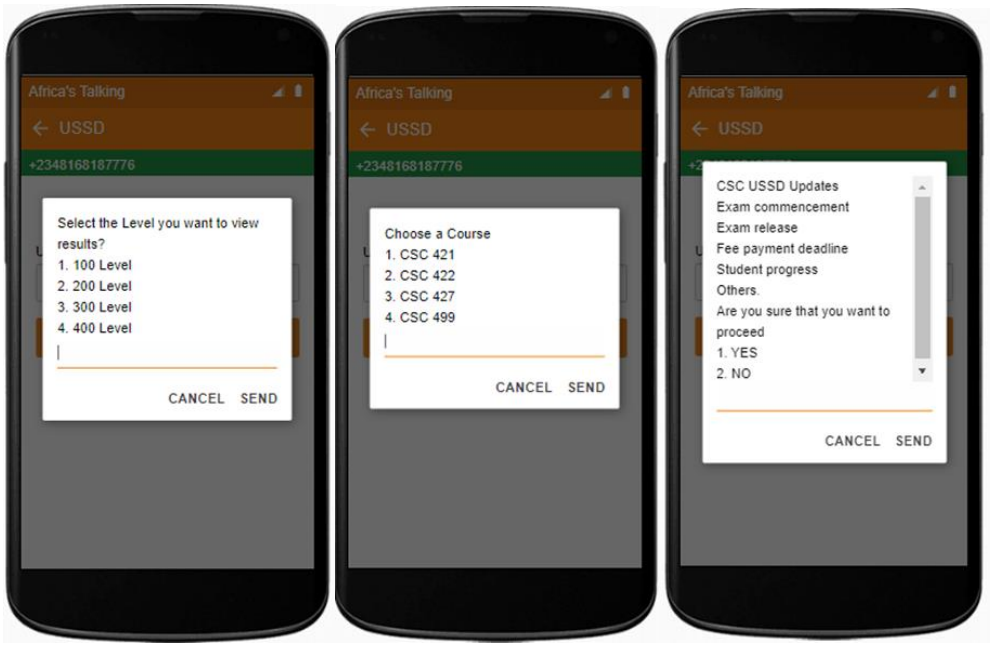

Figure 8: Sub Menu of the USSD application

3.2.5. End Session

By the end of each session, the corresponding output will be displayed to the student's screen. Figure 9 shows the end sessions and displayed information

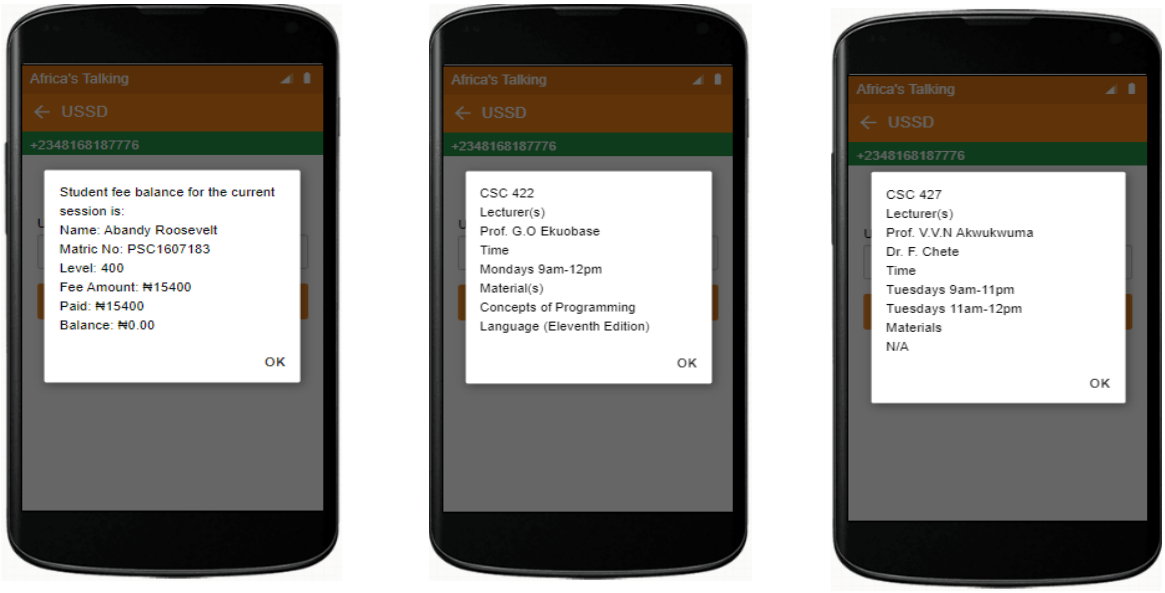

Figure 9: The end Session and displayed information

3.3. Testing

Testing is a part of the software process. Testing is an activity carried out at a specified interval to verify that the actual results match the expected and to ensure that the USSD application is error free. It can involve exceeding a system component to evaluate one or more properties of interest, identify errors, gaps or missing requirements. The tests conducted on the system are the functional test and include the following: -

i. Unit test: This is done on the software to ensure that each component or module of a system at the code level is functional and function as designed to. The unit test is the initial stage and will help to identify bugs at an early stage.

The unit test was conducted manually and was carried out on the development machine and each method, class and components in the system were isolated and tested across a range of valid and invalid inputs to ensure that they are working as expected.

Integrating testing: Integrating testing is a software testing where each unit is integrated with the other units to create a module or component and the components are then tested as a group.

The menu was moped up independently, after building a navigation structure to link each screen and each screen were thoroughly tested to confirm or ensure that the whole screen function as expected, and that the user navigation has a complete non-blocking from the beginning of the screen to the end. Table 1 depicts the integration test carried out for screen navigation.

Table 1 Integration test for screen navigation

Test Case ID	Test Case Objectives	Test Case Description	Expected Result
1	Check the interface for dialing up the code	Enter the USSD code to open the application and click call button	To be directed to the USSD application main menu
2	Check the interface for registration of the USSD service	Enter the user details for registration and click send button	Message is delivered and displayed on the screen
3	Check the interface to request academic service from the main menu	Enter a navigation number and click send button	To be directed to the USSD application sub menu
4	Check the interface to request academic service from the sub menu	Enter a navigation number and click send button	Message is delivered and displayed on the screen

3.4. Security challenges

The USSD technology is considered relatively more secure, when compared to SMS, because it does not store a copy of the message or data on the user's device (mobile phone) or the Short Message Service Center (SMSC) [13]. This is because a single session is established between the mobile terminal and the application server, and at the USSD gateway the message is encrypted, thus preventing data to be misused between the gateway and the server [13]. However,[14] posited that, the fact that data carried within the communication channel is not itself encrypted, is a big risk; consequently, this data can be then be accessed if GSM encryption is broken [8].

Furthermore, the security flaws of the GSM have been addressed in higher generations above the 2G systems [13]. In this regard, the 3rd Generation Partnership Project (3GPP), an umbrella term for a number of standards organisations which develop protocols for mobile telecommunication, have

replaced the weak crypto proprietary algorithms (COMP128, A5/1, A5/2) with a stronger encryption algorithm, KASUMI [13]. This algorithm, as submitted by [13], has been rigorously peer reviewed, thus making it more agreeable. In addition, instead of ending at the Base Transceiver Station (BTS), the encryption has been extended from the mobile to the base station controller [13]. PIN vulnerabilities are another security challenge in USSD networks. A study by [13] revealed that a customer PIN characters entered in the phone are not masked, thus making it visible to someone who may be watching. The study also revealed that the PIN used is only 4 digit numerals which makes it easy to guess. Weak pins leave the USSD based menu vulnerable to brute-forcing and guessing attacks [15]; thus, [16] in a study, posited that the loss of a person's mobile device often results in the possibility of criminals gaining access to the mobile banking PIN and other sensitive information. To address these PIN vulnerabilities, [13] suggested the PIN characters to be a combination of letters, symbols, and numbers, and also masking the PIN characters as they are being typed in. [13] further suggested enforcing periodic change of PIN, prohibiting the use of year of birth as a PIN, and restricting the use of a system's default value, as improvements to be made on server security policies. However, [1] as cited in [12] submitted that end-to-end encryption between a client (SIM toolkit or Java) on the handset and the application attached to the USSD Gateway is the only way of guaranteeing the security of such services.

3.5 Benefits of Deployment to Universities

The USSD technology does have some major advantages that could encourage its deployment to universities, amongst which are: easy to use, does not require the internet to function, low cost, speed, reliability, secure. In addition, users don't need a smartphone or high end phone to use the USSD platform [16]. The USSD, unlike an SMS message, does not offer a store-and-forward capability, as is typical of other short message protocols, but creates a real-time connection, instead [10]. That is, USSD enables two-way communication of information, as long as the communication line stays open, resulting in queries and answers nearly instantaneous [10]. In addition to the technology being beneficial and accessible to target users in regions where broadband is either non-existent or very poor, the cost of usage is affordable, as mobile network operator charges the USSD session cost from the either the user airtime or the USSD provider [17]. There are basically two types of session charges viz: the toll free charges, in which the provider of the USSD short code bears the charges of the USSD session cost[17] ; and the user charges, in which the users are charged from their airtime as per session cost and time duration while using the USSD service [17].
Thus, since there are no applicable data charges (thus can be used on basic feature phones), the USSD platforms is cost-efficient to the customer [18]. In addition, since the facility is supported by GSM networks (thus not requiring any need for investments), the platform is also cost effective for mobile operators [18]. The USSD platform, most importantly, is secure as it requires login authentication [18]. Thus, users can freely access it or be charged relatively low fees using methods such as pay-per-view [18]. In addition, it can be accessed anytime, anywhere since the USSD codes can be accessed where there is a mobile operator network (without the internet) ([19] and [20] as cited in [18]). Consequently, Universities can take advantage of the flexibility of the USSD session charges types to make a choice. However, it will be cheaper for both students and the University management to choose an option where the internet would not be required for communication.

The USSD platform described in this study is not intended to substitute the existing systems, but rather to enhance the reach of facilities to the target users, who are predominantly University students, using a popular, available, reliable, affordable and secure technology.
A similar assertion was also made by [1].

4. Conclusion

The study examined the integration of a USSD based application in Computer Science Department, University of Benin, Nigeria. The use of the Kofa Portal by students can be complemented by provision of an institutional USSD application to access the University of Benin Kofa Portal. The student must have records with the University of Benin (Computer Science) and only after this step can the student have access to the system. The student simply login using a unique matriculation number. The student can view and request for academic information. This process is possible for only students who have registered for the USSD application. The administrators' functions are to add lecturers, add courses, add result grades, add timetables, add tuition fees, add updates, etc.
The major limitation to this study is the cost of deploying the USSD gate way application for all the mobile network operators in Nigeria; thus, we restricted the application to Computer Science Department, University of Benin, Benin-City.

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