



DIGITIZING PROCESSED FOOD AND MEDICINAL PRODUCTS FOR CONSUMERS' SAFETY IN GHANA, USING BARCODE TECHNOLOGIES

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Abstract

Processed food and medicinal products are in most cases taken without taking conscious look at the shelf-life of such consumables. The realities are; a portion of the consumers check the validity of the products they consume provided the shelf-lives are clearly defined, while as majority of them do not even check the shelf-lives of consumable products they take. These realities result in catastrophes in scenarios where consumables taken had already expired.

This paper seeks to utilize Product Assurance (PA) application, which applies barcode technologies as a tool for digitizing processed consumables to enhance the consumer consciousness on processed food and medicinal products in Ghana. The PA has been programmed to run on web and android smart-devices and this enables consumers to scan, verify and check the validity of any processed products they consume easily. Moreover, the PA comes with SMS notification feature that sends products shelf-life status to its subscribers three months ahead of time.

Keywords: Product Assurance, Android Smart Devices, Consumable Food and Drugs Authority, Agricultural products, Inventory, Barcode.

1. INTRODUCTION

The survival of human life depends on essential commodities such as food, clothes, and health products [1]. The demand on these commodities however, initiates the need for agricultural products from farmers. Manufacturing companies transform raw materials received from farmers through series of machinery and biochemical stages and other safety precautions to produce processed products in larger quantities for consumers' usage.

The [2][3], [4] affirmed that the quality of the product sometimes become degraded to a level called cutoff limit, at this level, the product (item) is said to have attained its expiry period.

Along the production chain, processed products purchased from retailers are sometimes either in good shape or about to expire or it has expired, however, a portion of consumers pay attention to the best before dates labeled on products they purchase [5]. Some consumers upon realizing the bad state of a purchased item may return the products to the supplier, while others keep the item and dispose it later on; what happens to the consumers who use the expired products unknowingly [6]. In Ghana, Food and Drugs Authority (FDA) is the organization mandated to handle certification of locally manufactured and imported consumable products into the country before public usage.

2. CASE STUDY

Some processed consumable products imported into Ghana from her neighboring countries along the borders sometimes swerve the surveillance of FDA. FDA in accordance with the Public Health Act ensures public safety by destroying smuggled and expired products seized from traders in Ghana. The perished products deemed hazardous to public health [7]. Moreover, some retailers alter the expiry dates of their inventory mostly when they are about to be obsolete without considering the health of the consumers [8]. The question is; how can consumers validate what they consume if the workload is only on FDA? Again, how can the stakeholders on the production chain get notifications on the actual state of their inventory in a form of SMS or email?

3. RELATD WORKS



Fig 3.1: Barcode Structure Sample

Figure 3.1 shows a sample of a barcode structure. Barcode is an optimal machine-readable vertical stripes of lines pasted on items showing information of the item to which it attaches [9]–[11]. The barcodes made of dots and dashes were used to communicate electronically, the information of a grocery products, and [12] named the grocery store industry as Universal Product Code (UPC).

Using barcode technologies in monitoring the originality of products into the Ghanaian market is gradually gaining popularity in Ghana. [13] affirmed that consumers' trust increases on the products they purchase if barcode technologies are well structured and implemented.

Point-of-Sales shops serve as major users of barcode technologies for transacting their inventory to consumers. Instead of using keyboard to capture the codes of a barcode stripe on a label, they make use of barcode reader which facilitate the readings of the barcode stripes, thereby making their work easier and faster [14]. In situations where an inventory item has no barcode labeled on it, the inventory officers produce their own barcode to speed up their inventory monitoring [15].

mPedigree is a Ghanaian based company which uses mobile and web technologies to address industry challenges in production areas such as GTP Nustyle. Their innovation safeguards their clients' product against

counterfeiting while promoting effective traceability of products. mPedigree's technology is based on voucher code verification [16]. Figure 3.1 shows the process of mPedigree's products verification.

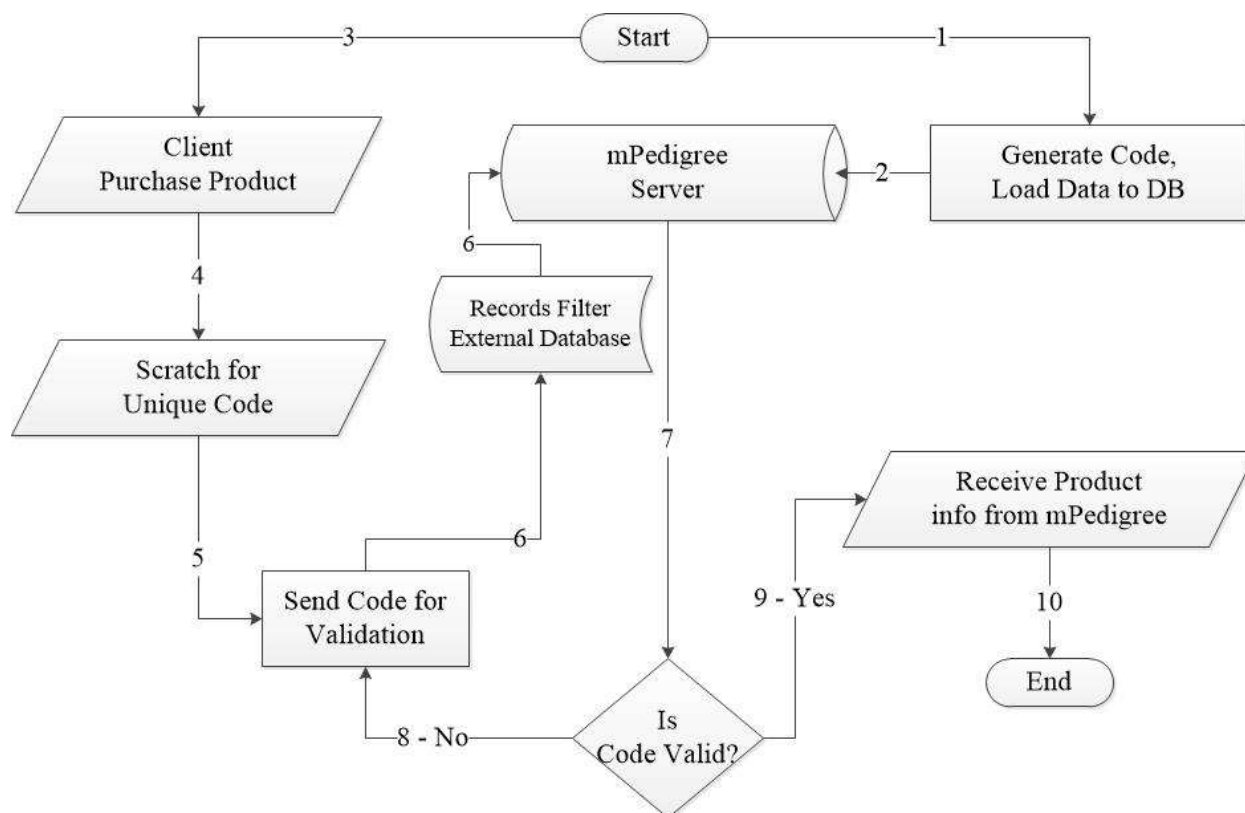


Fig 3.2: mPedigree's Product Verification Process Flow Diagram

In Figure 3.2, the company generates unique codes and stickers for every product and saved the codes onto their central database. Clients purchase the products respectively and scratch the sticker to access the voucher code captioned in it. The voucher code is entered onto a mobile device and sent to a toll-free number for validation. This code is filtered and sent through a decision module to confirm the originality of the code. If the code exists on the server then the product information is sent to the client via SMS [17].

Monitoring the tax payments and the originality of some selected processed consumable products such as bottled and other packaged water excluding sachet water, stout, malt drink, carbonated soft drinks, beer, including cider beer, whether bottled, canned, or packaged, spirits, wines, cigarettes and other tobacco products, the Ghana Revenue Authority (GRA) developed a mobile application known as Ghana Tax Stamp. This application uses dot matrix barcode technology [18].



Fig 3.3: GRA Tax Stamp Authenticator

In Figure 3.3, users of the Authenticator scan the dot-matrix barcode using the application and the scan result to the right displays if the product's record is the GRA database.

This paper intends to propose a hybrid technology system consisting of barcode technologies and android mobile application for the manufacturers, retailers and consumers to facilitate the monitoring, scanning and verifying of the products they purchase and consume.

4. METHODOLOGY

Both the design science and cross-section research methods were respectfully applied to develop the PA artifact and selection of some regions in Ghana for the study. The data were then captured using the PA application.

4.1 Conceptual Model of PA Application

Below are the main the entities and activities involve in the PA conceptual model and it depicts the relationship between the entities and database referred to Figure 4.1.

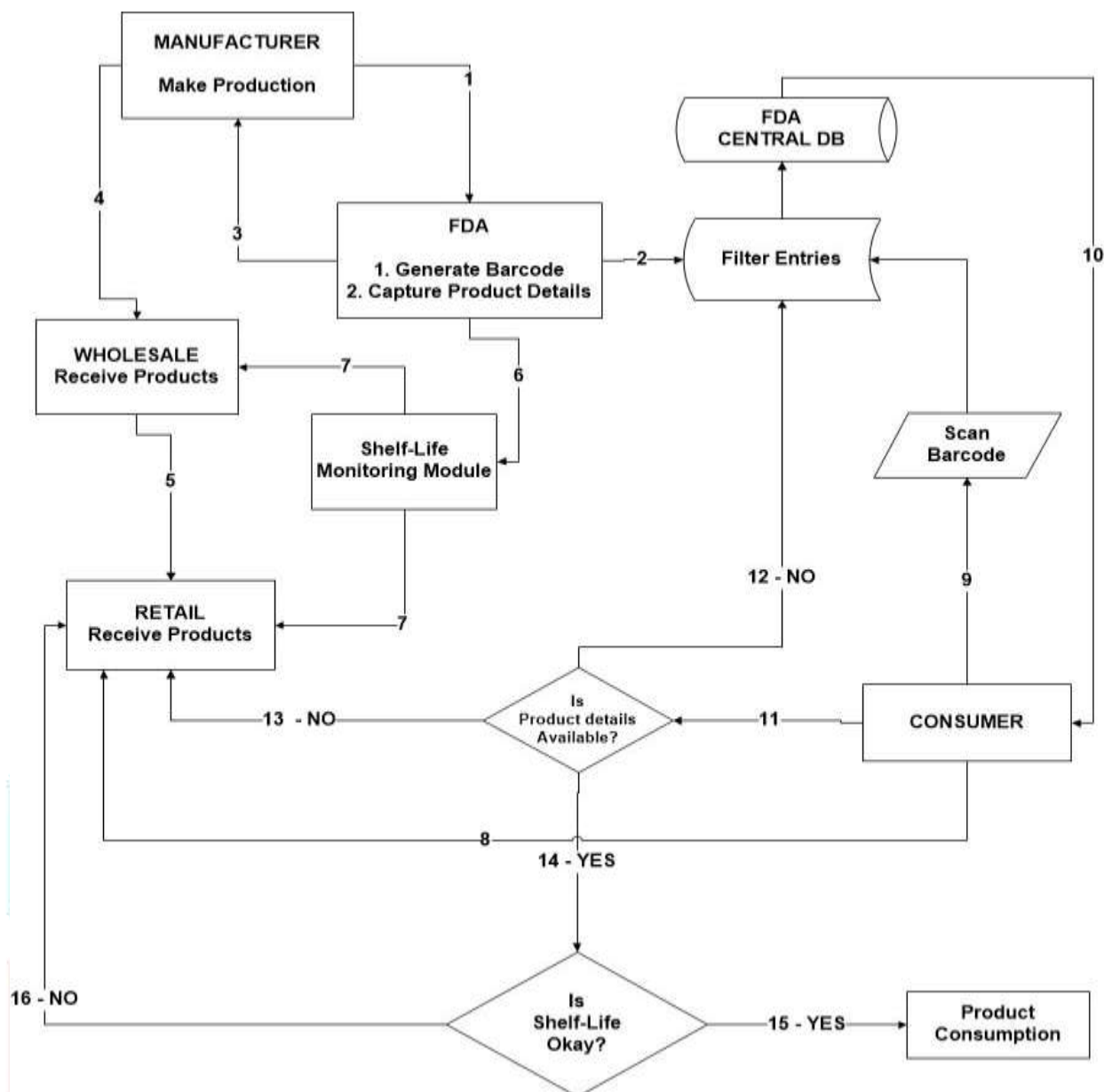


Fig 4.1: Conceptual Model of the PA application

4.1.1 Manufactures

Manufacturers produce their products and send them to FDA for assessments and verification. If there is no ambiguity in the results then, FDA proceeds to the next phase.

4.1.2 FDA

FDA accesses the products and generates a unique barcode for the production and captures the details. The captured details are first filtered to check if all the data received conforms to the data validation structure programmed in the system. The data is then saved on the FDA's central database.

4.1.3 Wholesalers and Retailer

The barcode generated from FDA is given to the manufacturer to be added to production labeling. Packaged products from the manufacturer are then distributed to the wholesalers where they transact retailing.

4.1.4 FDA Shelf-life Monitoring Model

A shelf-life monitoring intelligence is implemented in the system to be used by the FDA. This intelligence is responsible for monitoring the shelf-life of each product stored on the FDA's central database. The colors, red

and green indicators depict the status of each product either expired or not, respectively. Three months to the shelf-life limit for each product, the system sends SMS notification to the wholesalers and retailers for the necessary action to be taken.

4.1.5 Consumer

Consumers use the mobile application to validate the products they purchase from the various retailing point of sales. The consumer purchases the product from a retailer and scans the barcode on the product label; the application filters the code and performs a search from FDA's central database.

4.1.6 Searched Results

Result from the database is sent to the consumer's application in real-time. If the search returns an empty result, then the location of the consumer is sent to FDA in real-time to indicate that smuggled products are available in the area. The consumer then decides either to return or keep the products. Similarly, if the search returns details of the products, the expiry date or shelf-life limit, then the consumer confirms the information on the product label with the search results. The products in good status are either kept or returned, depending on the consumer's discretion.

5. Implementation of the PA Application

Computer aided software engineering (CASE) tools such as Android Studio, PHP Storm, and XAMPP were used in the development of the PA mobile application. Android Studio, PHP Storm, and XAMPP are programming tools. Android Studio uses Java and Extensible Markup Languages (XML) for its source codes and User Interface (UI) respectively. PHP Storm combined Hypertext Markup Language (HTML), Cascaded Style Sheet (CSS), JavaScript (JS), JQuery and Hypertext Preprocessor were used during the development of the Application Programming Interfaces (API) and web version of the PA. XAMPP was used to engineer the MySQL database of the application.

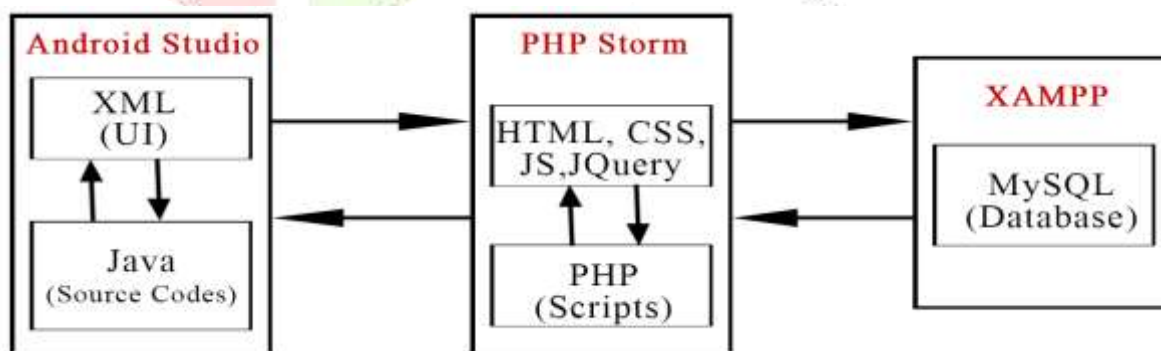


Fig 5.1: PA Development Structure

In Figure 5.1, Users interact with the PA through the UI. The Java source codes receive the entries from the UI and forward them to the PHP scripts (API). The API forwards each request to the database to fetch the results. These results are returned in a reverse approach through the API to their respective UIs.

5.1 PA Sub-Features

In Figure 4.1, the PA application was categorized into four main sections as; User registration, Load item, Verify product, and SMS notification. Below are the details of the PA sub-features.

5.1.1 User Registration

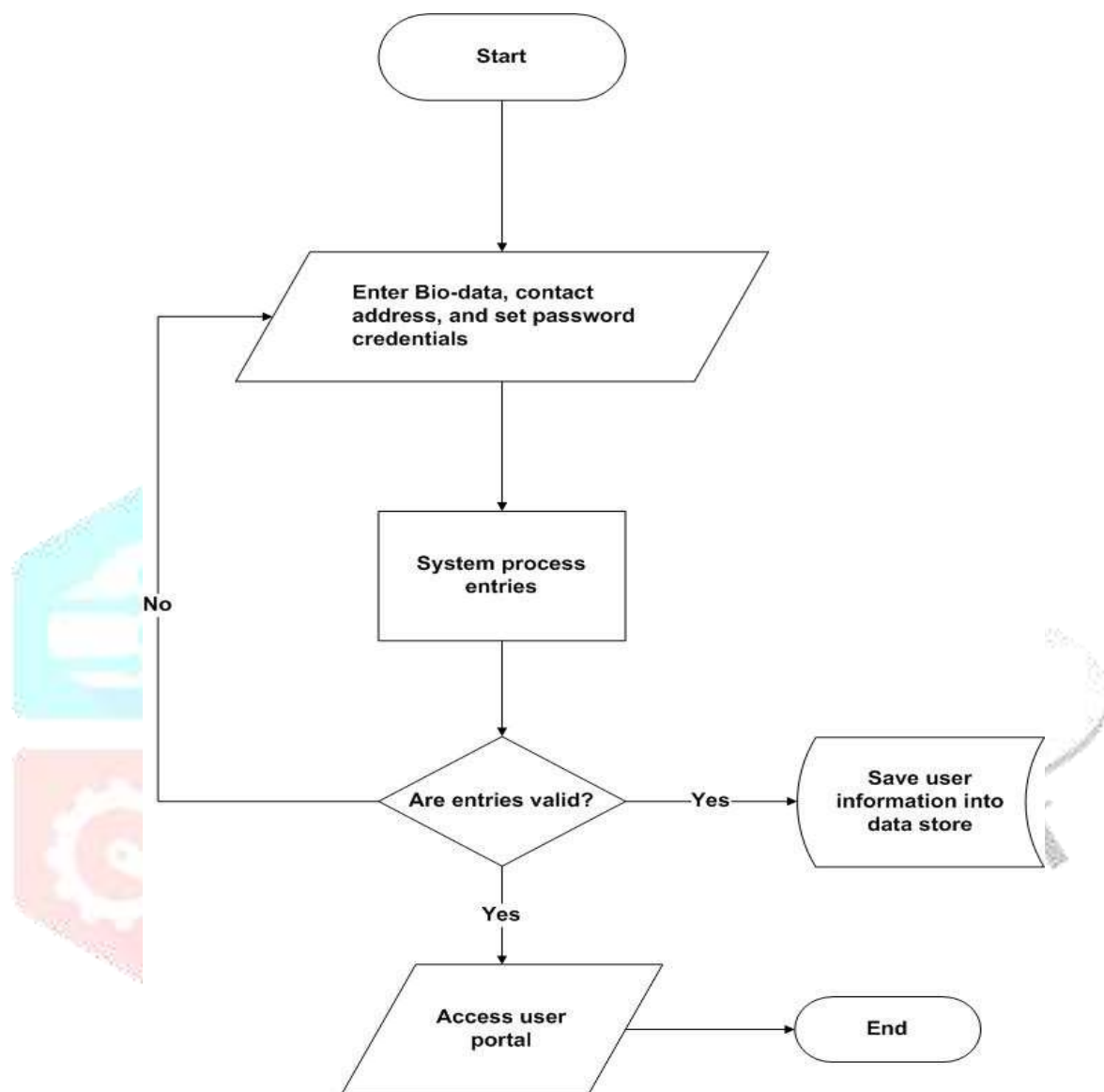


Fig 5.2: User Registration Process Flow

The User enters his/her bio-data per the interface requirements. The PA application validates the entries, and if the data provided are not valid, the user is required to vet his/her entries and resend the data for system processing. Else the data is stored into the FDA data-store (database). The user is then redirected to his/her main portal.

5.1.2 Load Item

To capture the details of any processed consumable products onto the FDA central database as presented in Figure 5.3, the user enters his/her login credentials. If the credentials are valid, access to the porter is allowed and the product information is submitted to the FDA database. However, if the credentials are invalid, access to the

porter to capture the item details is denied. The user is then required to vet the entries and resend the records to the FDA database.

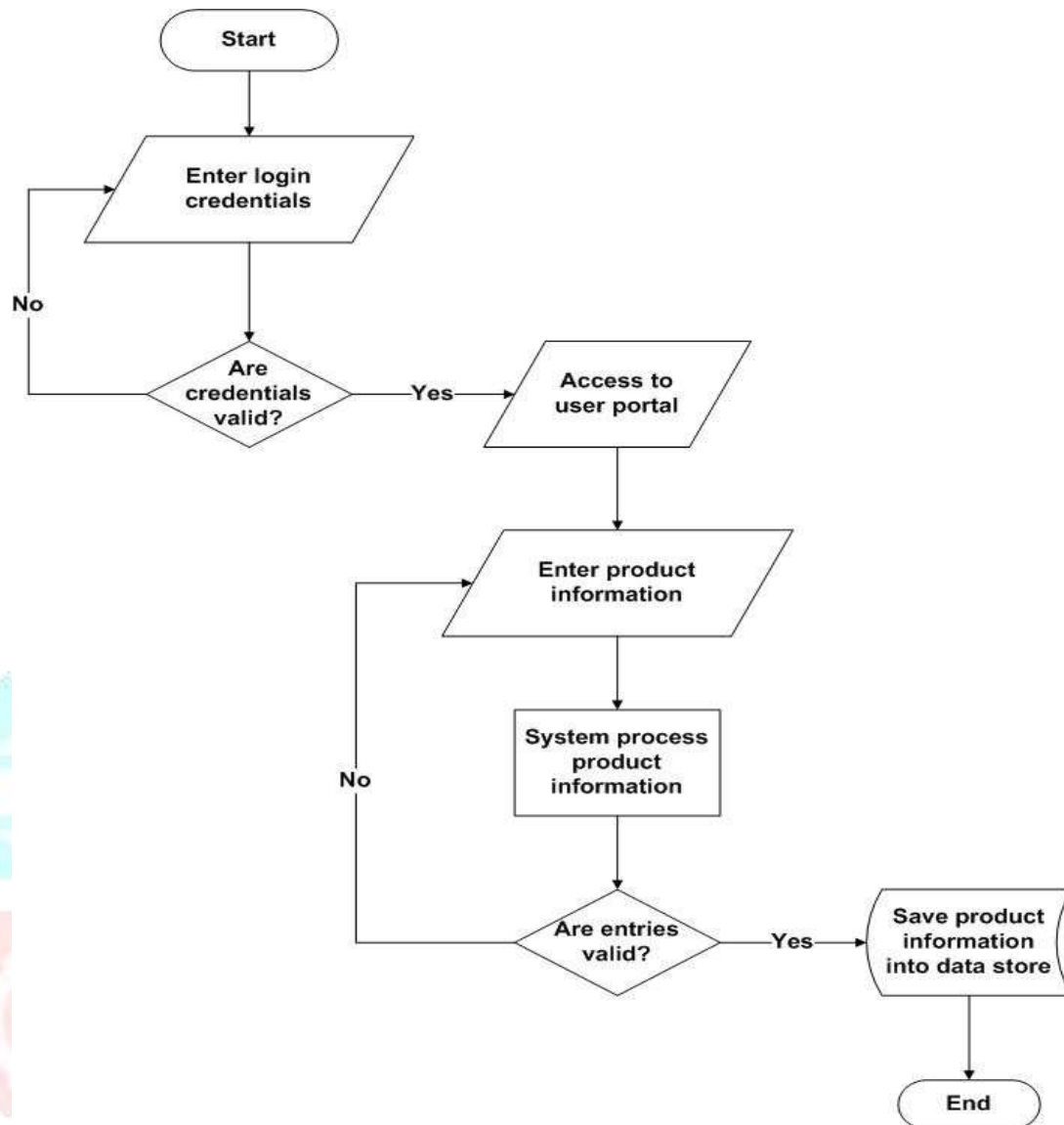


Fig 5.3: Load Item Process Flow

5.1.3 Verify Product

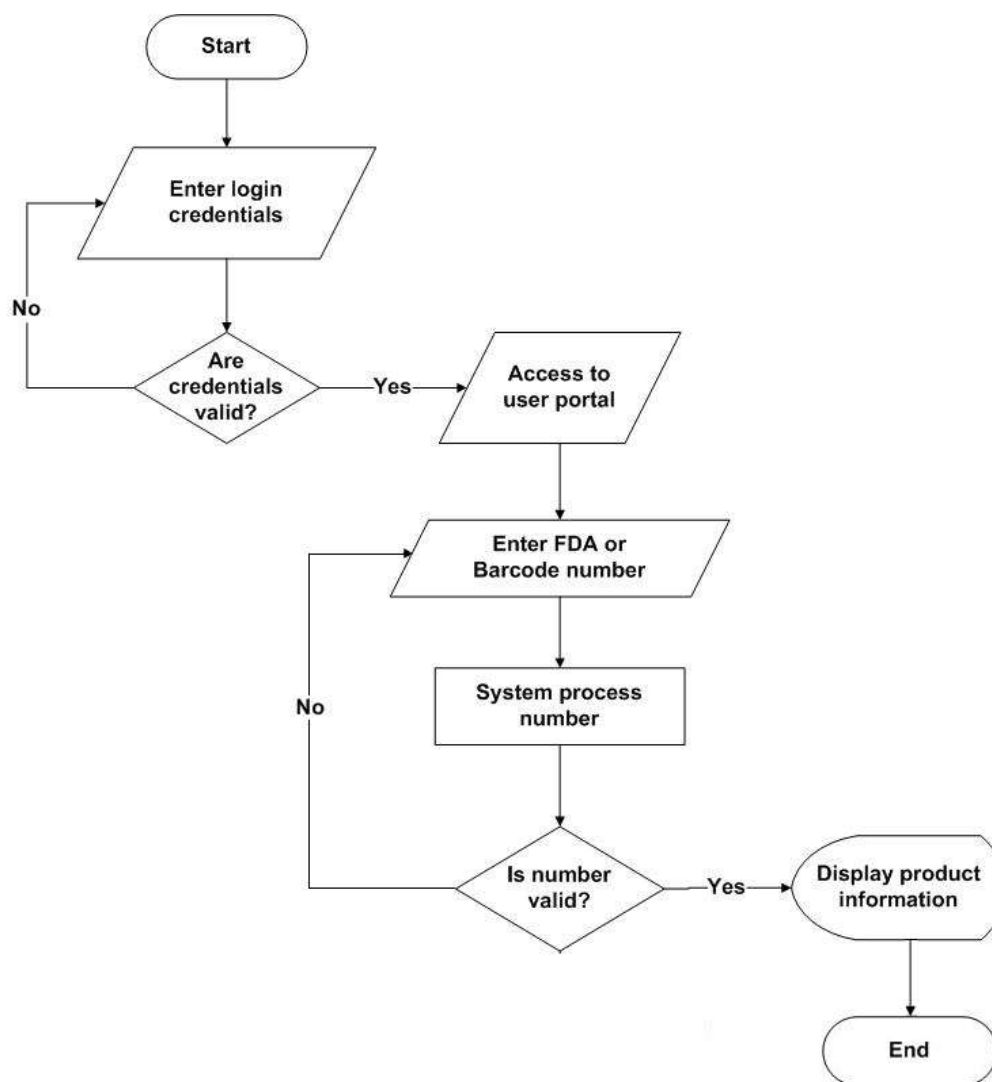


Fig 5.4: Verify Product Process Flow

For a user to verify products' validity using a barcode on the product's label, the user enters his/her login credentials. If the credentials are invalid, the user is requested to enter the correct credentials in order to get access to the verify product UI. With the product in hand, the user activates the barcode scanner within the PA application to read the product's barcode. After capturing the products barcode, the code is submitted to the central FDA database. If the records are in the database, then the results are displayed. If the records are not in the database, unknown response would be received.

5.1.4 SMS Notification

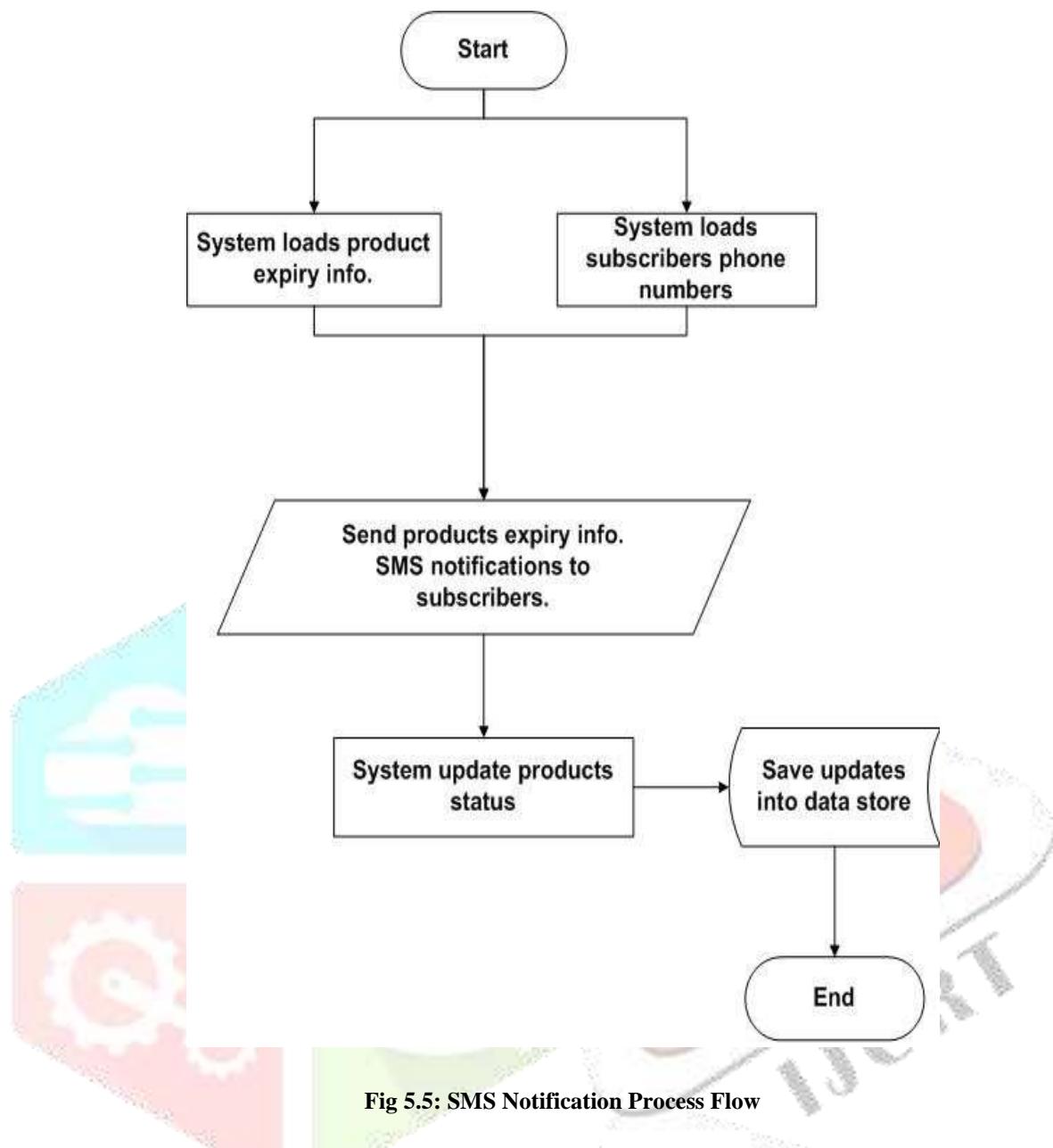


Fig 5.5: SMS Notification Process Flow

As indicated in Figure 5.5, the PA application sorts all the products that are three months due to expire. The PA application then loads subscribers' phone numbers. This helps to detect yet to be expired products information alert in a form of SMS. The products records are then updated and saved on the FDA database.

5.2 How to Use the PA Android Mobile Application

Users can assess the PA android mobile application on Google play store with the name, Product Assurance. They can however, use the link below to access the application as well;

<https://play.google.com/store/apps/details?id=com.techlabs.purgren.prodvalmain>

Users can also follow this link <https://www.youtube.com/watch?v=SU7WE0IwX0c&t=3s> to access practical tutorials on how to use the PA android application.

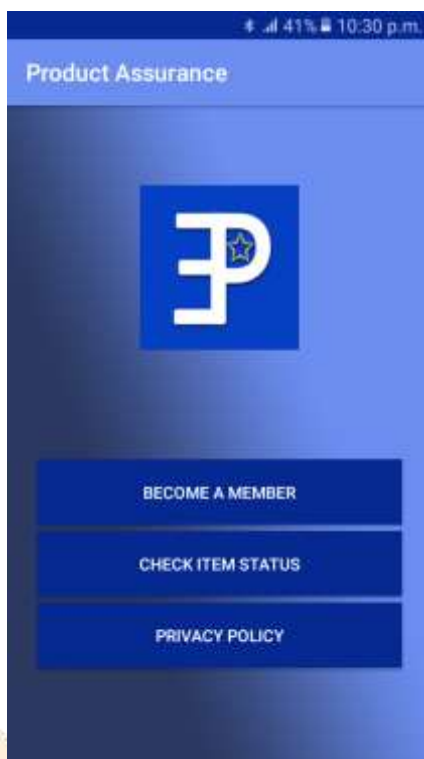


Fig 5.6: Home Screen of the PA Application

Figure 5.6 presents the index screen of the PA application when it is first launched. The screen has three (3) landing buttons, thus, Become a Member, Check Item Status, and Privacy Policy. The details of these buttons are explained in the sections below

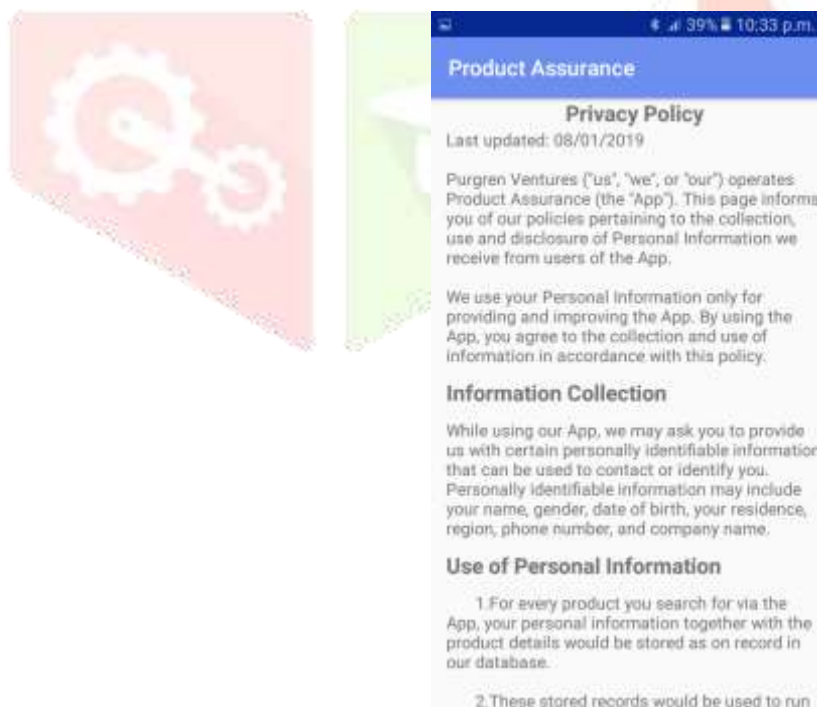


Fig 5.7: PA Privacy Policy Screen

The application makes the users aware of the underlined policies governing the use of the PA application, hence, Figure 5.7 pops-up when the Privacy Policy button is tapped. This policy changes periodically to keep the users updated on the new features and other changes that are added to the application as and when it is needed.

However, if a user of the PA application refuses to periodically read the Privacy Policy and acts on the contrary to the agreed policies concerning the application, then s/he would be sanctioned accordingly.

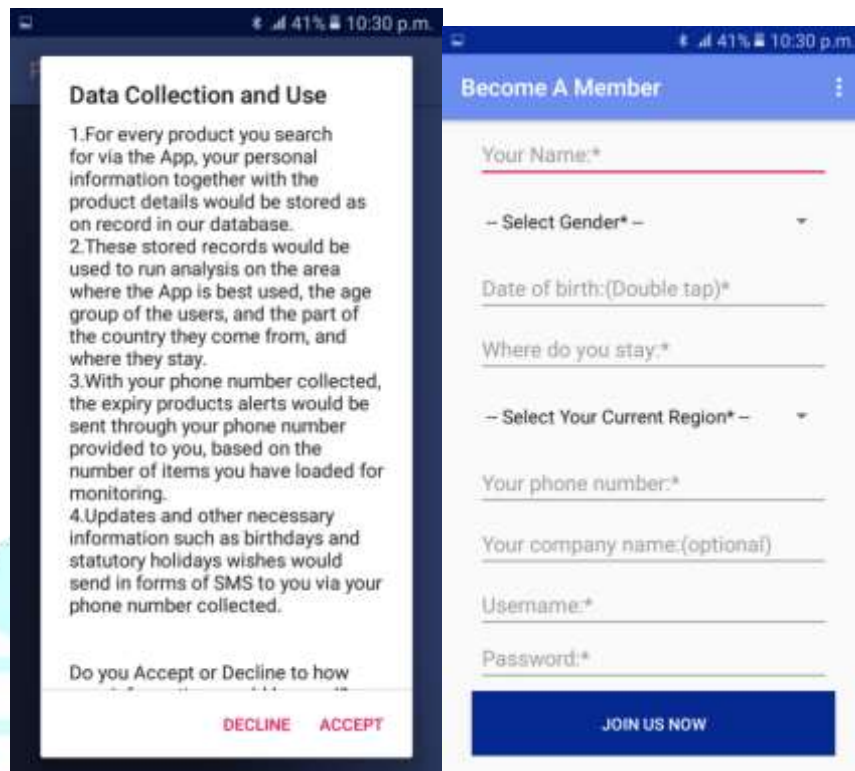


Fig 5.8: Data Collection and Use Agreement and User Sign Up

Figure 5.8 loads up when the Become a Member button is tapped. The first screen that loads up is the Data Collection and Use (DCU) which informs the user on how his/her data would be used for, at this point, if the user wish to continue to be a member of the PA application then, s/he would have to accept the agreement and proceed to become a member.

The second screen loads up for the user to provide the required biodata upon which after submitting would qualify the user as a full member of the PA application fraternity.



Fig 5.9: Validating Item using Barcode

When the user taps on the Check Item Status button in Figure 5.6, Figure 5.9 loads up. The user is then required to tap on in field that is captioned, “Tap to Scan Barcode Number”. This would then convert the user’s phone back camera into a barcode reader, granting the phone to be able to scan the barcode number into the PA application.

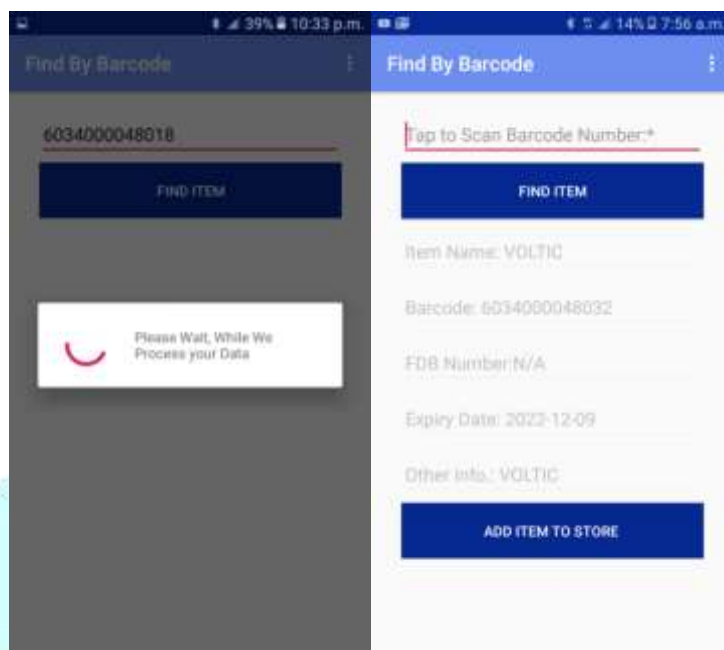


Fig 5.10: Barcode Validating Results

When the camera is able to read the barcode on the item’s label, the code is read into the assigned field on the PA application. The user taps on the Find Item button to initiate the search process as indicated in Figure 5.10. The application displays the search results after a successful search from the FDA central database.

5.3 Test Results and Analysis

The products from five large retailing shops, pharmaceutical companies and pharmacies in Ghana were purposively sampled to test the PA prototype. Three thousand six hundred and seventy-eight (3678) medicinal and non-medicinal products were captured into a temporal central database. The data capturing started on December 1, 2018 and ended on February 23, 2020. This exercise focused on the expiry dates of the loaded data. Table 5.1 presents the state of the captured data from the entry date till February 23, 2020.

Table 5.1: Data Captured from December 1, 2019 to February 23, 2020

Type of Product	No. of Products	State	Counts	Percentage (%)
Medicinal	1355	Good	1024	75.6
		Expired	331	24.4
Non-medicinal	2323	Good	2010	86.5
		Expired	353	13.5
TOTAL	3678			

Table 5.1 depicts the statistical analysis of medicinal products captured in the PA database over the period of observation. Out of 1355 medicinal products in the database, 1024 of the products were in good state (75.6%) whilst 331 of the products were found expired (24.4%). Similar observations were made about non-medicinal products. Out of a total of 2323 non-medicinal products, 2010 were in good state (86.5%) and 353 have expired (13.5%).

These observations are clear indications that the proposed Product Assurance application could assist in raising the consumers and retailers awareness' on products they transact in the market. The consumers stand the chance of verifying any of the products they purchase from any of the shops. Through periodic SMS notifications to the Pharmaceutical companies and Pharmacies, the companies could take the following actions to avoid loses;

- (i) To bring the yet to expire product to the forefront of the counter to be sold faster
- (ii) To separate the expired products from the yet to expire products.

6. Discussions and Conclusions

There are drawbacks in using the tax stamp and mPedigree's technologies to validate consumable products. The users have to dial approximately twelve digits code. Human errors due to eye defect might cause increase in request time and, thus reduce consumers' interest in using the technology. In addition, consumers often find it extremely difficult to validate the originality of some products in the market because the GRA Tax Stamp Authenticator which is a sticky paper on the products had worn-off. The PA application bridges these gaps. It serves as a beneficial tool for all the stakeholders along the production chain. The records of all imported and locally manufactured consumable products are saved on PA application central database. As a result, FDA is able to effectively regulate barcodes on all consumable products, making sure there are no clashes in the usage of the existing barcodes.

Finally, with PA application system, users are able to scan, receive SMS notifications and validate their consumable products using barcodes which are practically available on almost every consumable product in Ghanaian market.

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